Publication No. 64

Instructional Material

Series (T): 10

INSTRUCTIONAL-CUM-PRACTICAL MANUAL

On

ELEMENTS OF ELECTRICAL TECHNOLOGY

for

LINEMAN VOCATION CLASS-XII

Contributors:

Dr.V.K.Bhansali
Shri J.L.Kanakriya
Shri G.S.Srinivasan
Shri M.P.Mittal
Shri V.G.Phadke
Shri G.V.D.Singh
Shri Yash Pal Kapoor
Shri Syed Nas r ali
Shri . .Manikyaraja
Shri P.B.Sh sh
Shri .P.V rma
Shri S.Ray

(Experimental Edition)

1984

DEPARTMENT OF VOCATIONALIZATION OF EDUCATION

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

SRI AUROBINDO MARG, NEW DELHI-110016

PREFACE

Ever since the introduction of Vocational Education in our School System by Several States and Union Territories in our Country, the paucity of appropriate instructional materials has been felt as one of the major constraints in implementation of the programme and a source of great hardship to pupils offering Vocational Studies at the higher Secondary stage.

The Department of Vocationalization of Education (DVE) of the National Council of Educational Research and Training (NCERT), New Delhi has started a modest programme of developing instructional materials of diverse types to fill up this void in all major areas of Vocational Education. The task is too gigantic to be completed by any single agency but the model materials being developed by us might provide guidance and impetus to the authors and agencies desiring to contribute in this area. These are based on the national guidelines developed by a working group of experts constituted by NCERT. The present Manual is on ELEMENTS OF ELECTRICAL TECHNOLOGY for Lineman Vocation Class-XII. It contains practical exercises to be performed by the students with simple steps to follow, precautions to be taken and data to be observed and recorded in observation sheet. Each experiment is complete with specific objectives, theoretical information, behavioural outcome and questions for evaluation, etc. It is hoped that the students will find them immensely useful.

The pages that follow contain a draft of the manual which will be finalised after obtaining the feedback from the students, teachers and others concerned. The materials will then be published in printed form.

The users are requested to complete the questionnaire appended and return the same to us. Comments and suggestions for improvement of the material are cordially invited.

The material has been developed by a group of experts as authors in a Workshop held at the Advanced Vocational Training System, Industrial Training Institute, Faridabad from 24 February to 2 March 1984. Their names are mentioned elsewhere and their contributions are admirably acknowledged. This material was edited and finalised by another group of experts at our Deptt. from 9 to 12 March 1984. Our thanks are also due to the experts for taking pain to varyfy the authenticity of contents of the Manual. Shri Sachchidananda Ray, Lecturer in Technology deserves special thanks for editing and bringing the material in the present form. The assistance rendered by the Staff Members of ITI, Faridabad and DVE, NCERT for bringing out this manual is also thankfully acknowledged.

New Delhi
August 1984.

ARUN K MISHRA
Professor and Head
Department of Vocationalisation of Education
National Council of Educational Research and Training
Sri Aurobindo Marg, New Delhi-110016.

INTRODUCTION

The Vocationalization of higher secondary education in the 10+2 pattern of schooling has been introduced by Several States and Union Territories in the Country. The implementation of this programme received further encouragement by the Conference of Education Ministers in 1981. With the priorities laid down in the sixth plan a few more States are seriously planning to Switch over to 10+2+3 pattern of education and to implement Vocationalization at the plus two stage.

The implementation of the programme for the States and Union Territories has revealed that there is a great dearth of appropriate instructional materials. Since the vocational Courses laid a great emphasis on practical training it has become necessary to prepare Instructional-cum-practical Manuals best suited for these courses. The absence of appropriate instructional material has been one of the major constraints in the implementation of the programme and a source of great hardship to students offering Vocational courses at the plus two stage.

To develop models of instructional material, the Department Constituted a Working Group to formulate guidelines for the development of instructional materials and to prepare brief examples units. National guidelines were developed by this Working Group for preparation of instructional material.

The manual on ELEMENTS OF ELECTRICAL TECHNOLOGY for Lineman Vocation Class-XII has been developed based on the guidelines recommended by Working Group. This manual is

envisaged to help both teachers and students. Each experiment is complete with specific objective, introductory information and related theory, equipment and materials, diagram, procedure, record of observation, precaution and questions for evaluation. In order to acquaint the students about each experiment, the teacher should provide them with required theoretical knowledge or information related to the experiment. This will help the students for proper understanding of the experiment and enable them to perform the experiment properly and effectively.

In order to meet the stipulated objectives, the experiments include the study and operation of tools and instruments which a lineman would be required to use in his professional career, operation of machines, visit and study of Sub-station, Power-station and Factory. It is believed that the time spent in the laboratory and the field study will help the students to acquire sufficient confidence to handle his job with diligence.

The evaluation of the experiments performed by the students shall be based on the specific objectives. The teacher shall evaluate all the aspects which are relevant to achieve the specific objectives. This will contribute towards the "expected behavioural outcomes". Evaluation is an important aspect of performing the experiments. Each experiment should be assessed through evaluation based on knowledge, acquired skills and competencies, attitude and aptitude towards work, experiment performance,

application, maintenance of experiment record. Tabular representation of suggested evaluation scheme is given below:

Sl. No.	Components	Marks allotted	Marks obtained
1.	Knowledge	20	
2.	Acquired Skills and Competencies	35	
3.	Attitude and Aptitude towards Work.	15	
4.	Experiment performance	10	
5.	Application	10	
6.	Maintenance of Experiment Record	10	
	Total Marks	100	

At the end of each experiment, some questions for evaluation are given. The students shall answer these questions after the completion of each experiment and teacher shall examine them. If required, necessary corrections and suitable suggestions should be incorporated by the teacher. However, the answer to these questions should not be considered for the purpose of awarding final grade or marks.

C O N T E N T S

EXPERIMENT/PRACTICAL NO: 1

TITLE OF THE EXPERIMENT/PRACTICAL

Measurement of voltage, current, power and Power Factor in a Practical A.C. Circuit.

SPECIFIC OBJECTIVES

1. To learn to connect voltmeter, ammeter, wattmeter and Power Factor meter in a Circuit.
2. To measure voltage, current, power and power factor in a single phase AC Circuit having resistive load.
3. To measure voltage, current, power and power factor in a single phase AC Circuit having inductive load.

INTRODUCTORY INFORMATION AND RELATED THEORY

If a purely resistive load (like lamp bank or fixed wirewound resistor etc.) is connected to single phase AC Supply, then the power consumed in the load is the product of voltage measured V and the line current I. The current is in phase with applied voltage and the power factor is unity (one), wattmeter reading will be same as Volt x Ampere product.

Most electrical loads in practice are inductive in nature i.e. a combination of resistance and Inductance such as induction motor, fan, choke. In this case the line current "I" is not in phase with the applied voltage as it was in case of pure resistive load.

The current lags behind the voltage by an angle ϕ as shown in figure 1 and 2.

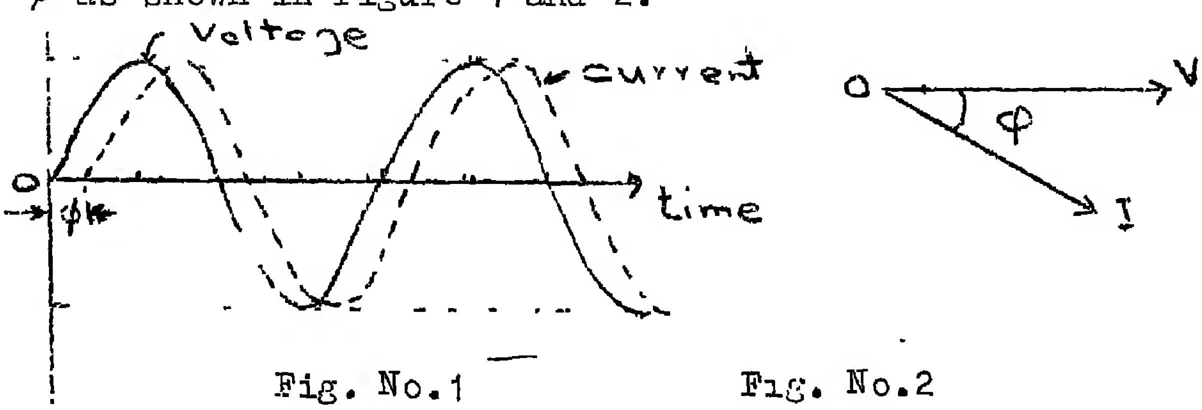


Fig. No.1 Fig. No.2

Cosine of angle ϕ is called power factor.

The line current I is the vector sum of two currents.

1. I_1 the inductive current lagging the voltage V by 90^0

2. I_R the resistive current in phase with the applied voltage

This is shown in Fig. No.3 below:

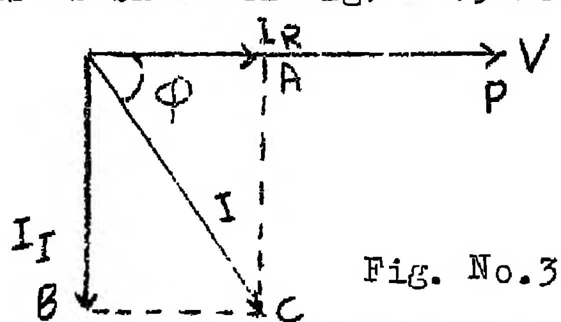


Fig. No.3

It will be observed that the wattmeter reading is lower than the product of voltage and current.

In Direct Current Circuits power p = V x I where as in alternating current circuits power = VxIxCos φ where Cos φ is the power factor of the Circuit.

EQUIPMENT AND MATERIALS

Sr.No.	Item	Quantity
1.	Variable ratio Auto transformer	One
2.	Voltmeter 0-300V AC	One
3.	Single phase wattmeter 250V 5A	One
4.	Lamp bank(as available)	One
5.	Single phase AC Motor 1 H.P.	One
6.	Power Factor meter 250V 5A	One
7.	Ammeter 0-1 Amp.	One
8.	Ammeter 0-5 Amp.	One

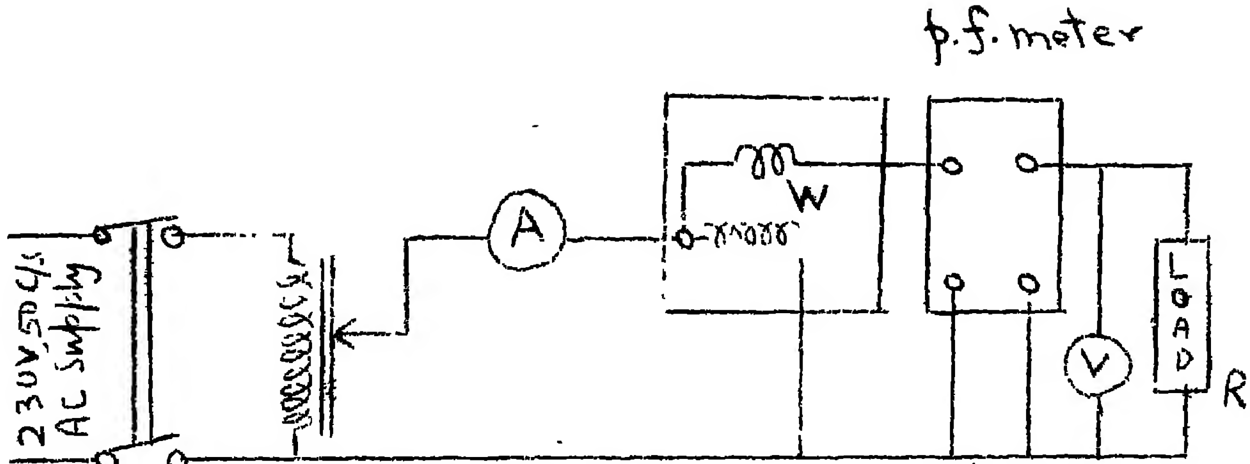


Fig No.4

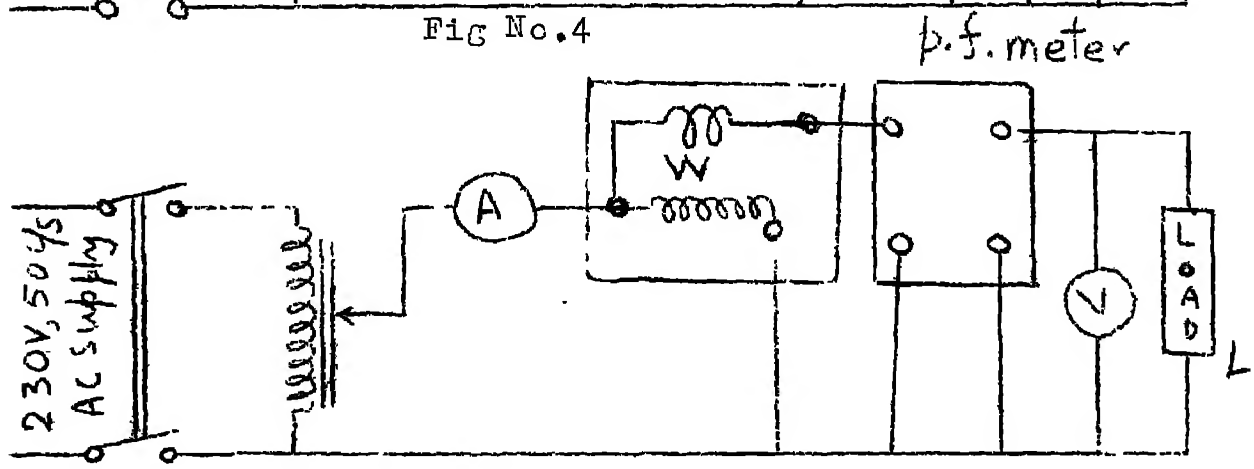


Fig. No.5

PROCEDURE

Part I

1. Study the connection details of Wattmeter and power factor meter.
2. Determine Wattmeter constant.
3. Connect the circuit as per figure No.4
4. Put the auto transformer at minimum voltage position before start.
5. Put the supply on and measure the voltage, current, power and power factor for different input voltages.
6. Record all the readings in observation table No.1
7. Bring back the Auto transformer to minimum position and switch-off the supply.

Part II

1. Connect the circuit as per figure No.5
2. Put the supply on and measure the readings of Voltmeter, Ammeter. Wattmeter and power factor meter.

3. Record all the readings in table No.2
4. Repeat the reading for different voltages.
5. Record the readings in observation table No.2.
6. Bring back Auto-transformer to minimum position

   Switch off the Supply.

TABULAR RECORD OF OBSERVATION

TABLE NO.1

S.No.	Load	V (Volts)	I (Amp.)	W (Watts)	Power factor meter reading	$\frac{W}{VI}$	Remarks

TABLE NO.2

S.No.	Load	V (Volts)	I (Amp)	W in Watts	Power factor	$\frac{W}{VI}$	Remarks

PRECAUTIONS

1. Check zero error of all instruments.
2. Take the readings of the instruments after removing parallax
3. Bring back variable ratio auto-transformer to minimum position after taking the readings.

QUESTIONS FOR EVALUATION

1. Name the two coils of a watt meter.
2. What do you mean by pure resistive load?
3. What do you mean by pure inductive load?

   What will be the value of power consumed in this type of load?
4. Why an ammeter is connected in series and a voltmeter in parallel?
5. What happens, when an ammeter is connected in parallel?

REFERENCES

1. Electfical Engineering Experiments

U M A S Bhatnagar.

2. A Laboratory Course in Electrical machines

Kohli & Jain

EXPERIMENT/PRACTICAL No.2

TITLE OF EXPERIMENT/PRACTICAL

Use of megger for measuring resistance/continuity.

SPECIFIC OBJECTIVES

1. To set the Megger before use.
2. To use Megger for checking continuity
3. To use Megger for checking insulation resistance.
4. To choose the correct Megger for testing.

INTRODUCTORY INFORMATION AND RELATED THEORY

All electrical appratus and installations have their live parts insulated from the earth or body by insulating materials. In many apparatus like transformers motors etc. where more than one winding is used they are not only insulated from body, but also from each other. The safety of electrical apparatus and installation depends mainly on the condition of insulation. The state of their insulation can be found by measurement of insulation resistance.

Any equipment or installation will work if there is proper continuity in the current carrying cable, coil or a filament. MEGGER is the most versatile and Reliable test instrument used for above purposes. The value of insulation is expressed in terms of electrical resistance, the practical unit being the Megohm (10^6 ohms). The test set directly indicates on a scale the insulation resistance of the apparatus or installation under test.

There are three types of Meggers in common use:

1. Ranges upto 50,000 Megohms, 2,500 volts. This instrument is recommended for testing high tension equipment, transformers, mains etc.
2. Ranges upto 2000 Megohms, 1000 volts. This is a convenient instrument commonly used. This is

recommended for testing power circuits, motors etc. operating on voltage not exceeding 500 volts.

3. Ranges upto 50 Megohm, 500 volts. This is suitable for testing house wiring and other lighting installations, Small motors etc. operating on voltages not exceeding 230 volts.

1000 volts and 500 volts Meggers also comes in twin scale, enabling for testing continuity in addition to the insulation resistance. The instrument incorporates a simple changeover switch enabling either scale to be used at will. Typical scales of different Megger are shown in fig (1). It may be noticed that the scale is reverse as compared to voltmeters, Ammeters etc., i.e. zero on Right hand side and infinity on the left hand side.

TYPICAL SCALES OF INSULATION TESTER

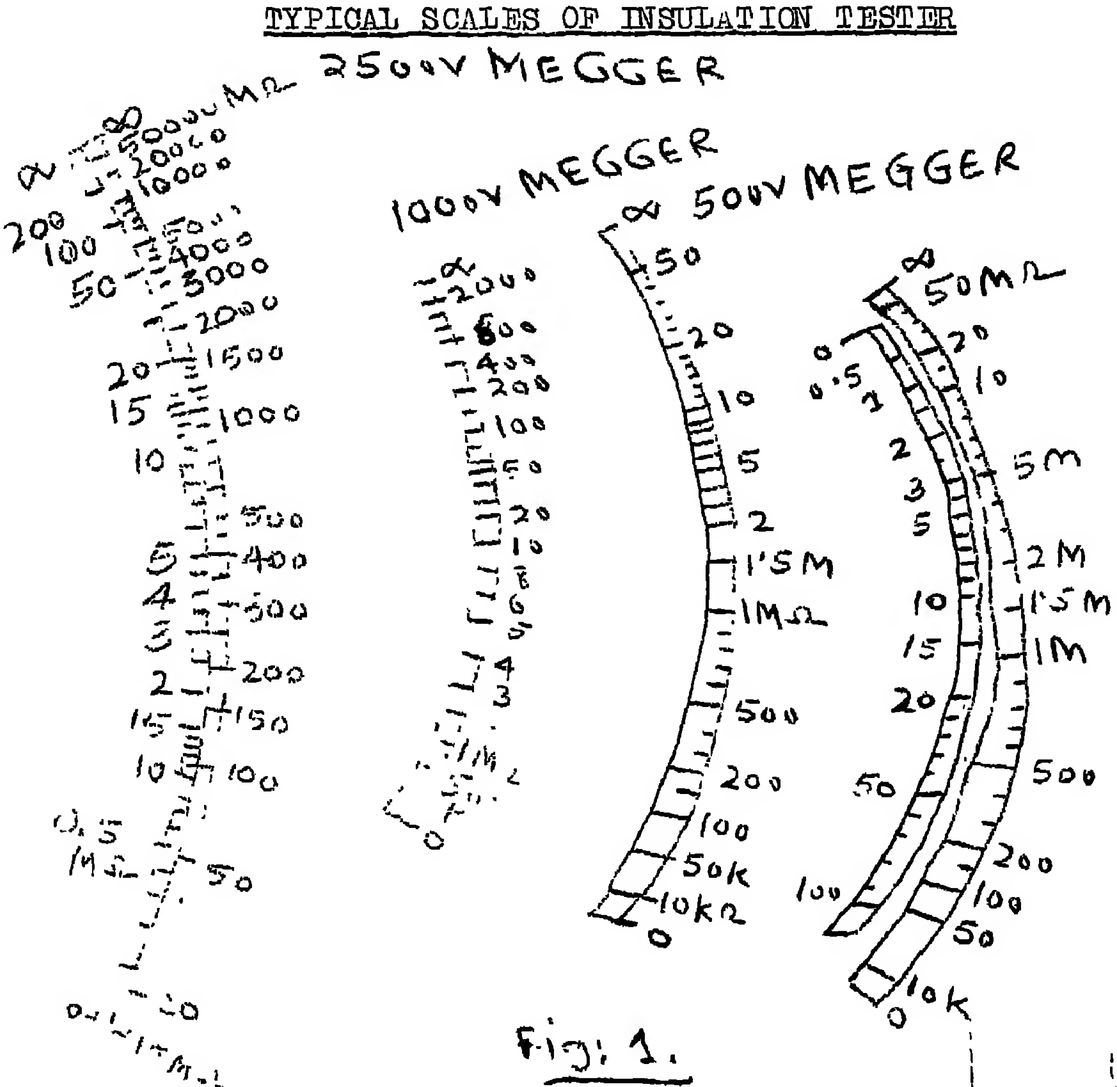


Fig. 1.

PRINCIPAL OF OPERATION

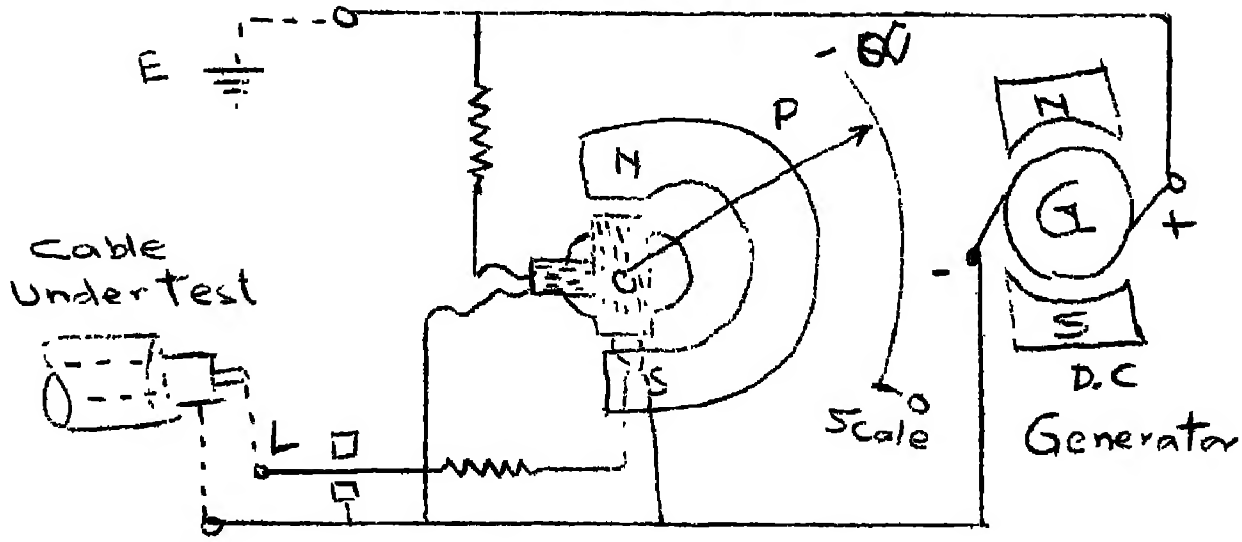


Fig.2

Every Megger is a combination of a hand driven D.C. generator and a direct reading ohm-meter. No external power source is required to operate it. The ohm-meter contins no control spring, being replaced by a control or pressure coil connected across the generator in series with a fixed control circuit resistance. The pointer therefore takes up a definite position only when the generator handle is turned.

The deflecting or Current coil is also across the generator and is in series with the resistance under test. Fig.2 shows the details of its construction.

The instrument measures the ratio of currents in the two coils, which depends only on the value of the resistance under test and not on the variations in the voltage generated due to the varying handle speeds because later affects both the coils in the same proportion. The instrument is therefore a true ohm-meter provided with its own energy source and is calibrated in Megohms and Kilohms.

When the Megger is operated with its terminals L and E open, current in deflecting coil is zero and current exists only in control coil which causes the deflection of the moving system such that pointer shows infinity.

When the Megger is operated with its terminals L and E short circuited deflecting coil current is more causing the moving system to deflect to show zero on the scale.

To guard against surface leakage, instruments scaled up to 500 Megohms or over are fitted with guard terminals (G) for connection as shown in the figure 2. Leakage current is thus returned directly to the generator without passing through the deflecting coil of ohm-meter.

Transistorised Meggers are becoming popular now-a-days. In these Meggers, hand driven generator is replaced by an Electronic Circuit which produces the desired test voltage by using a dry battery. Megger can be put into operation just by pressing a button on it instead of rotaining the handle.

EQUIPMENT AND MATERIALS

1. Megger 500 V or 1000 V (Hand operated type)
2. Megger (Transistorised)
3. Test leads with clips
4. Equipment for test:
   Such as Motor, Heater, Transformer
   Available length of Cable etc.

5. CIRCUIT DIAGRAM

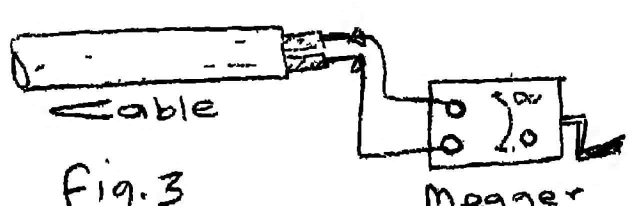
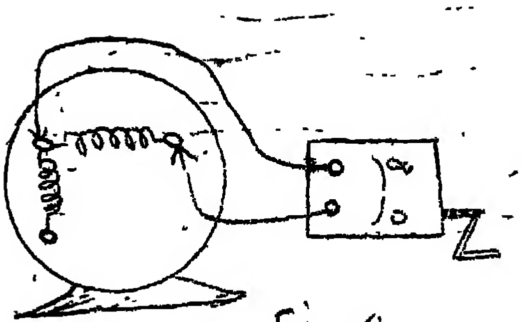


Fig.3

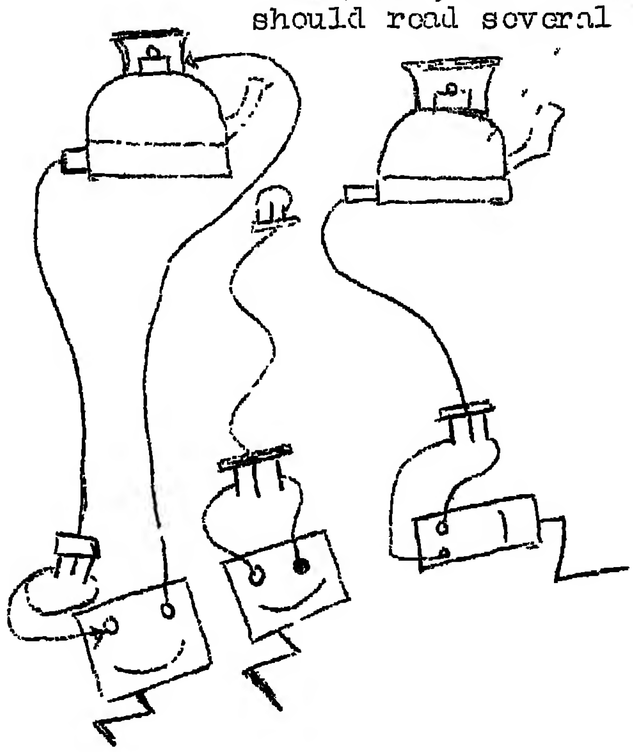
To check the insulation, resistance between the two cores of a cable (if the cable is good megger should read several Megohms).



To check continuity between the two terminals of a winding (if the continuity is good megger should read zero)

Fig.4

To check insulation resistance between body and winding connect one terminal(L) of Megger to winding and other (E) to body. The megger should read several Megohm.



Test 1 - To see if electrical element has made accidental contact with body(Insulation Resistance between element and body) - should read several Megohms.

Test 2 - To see if the insulation of the flexible cord is sound (insulation Resistance between Conductors) - should read several Megohms.

Test 3 - To see the continuity of the complete Circuit - should read Zero.

PROCEDURE

1. Place the instrument on a flat surface so that the handle may be turned conveniently.

2. Without making any connections rotate the handle and observe the pointer. The pointer will move over the scale and stand over the infinity mark.

3. Connect test leads to Megger terminals L & E, short them together, turn the handle, and observe the pointer. It will move on the scale and stand over the zero mark.

   NOTE In case of transistorised Meggers do the above tests by just pressing the test button on the instrument.

   This confirms that the instrument is good for use.

4. Connect the Megger test leads to the circuit to be tested as shown in figures 3 to 7, turn the handle at

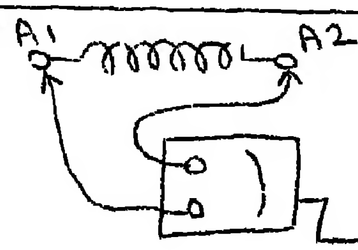
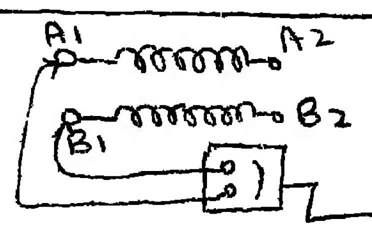
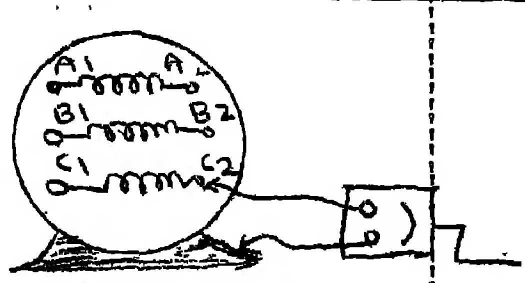
about 160 rpm, and while turning the handle observe the position of the pointer on the scale. This shows the value of insulation resistance under test or the continuity as the case may be (in transistorised Meggers, press the test button).

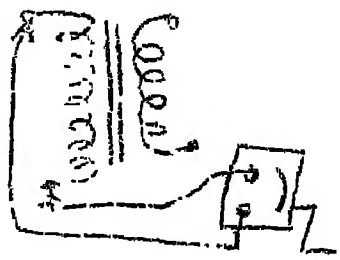
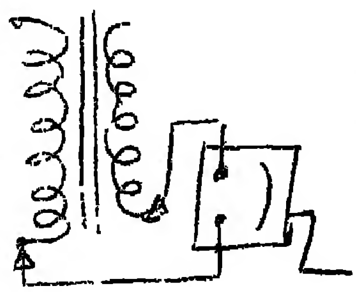
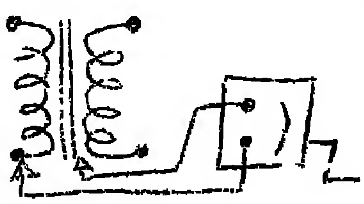
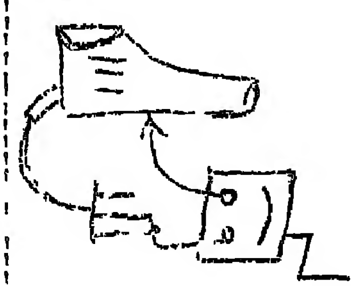
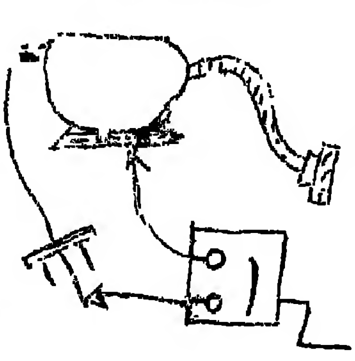
5. Conduct the Megger test as per the table. Record the Megger Readings and the condition of the equipment.

   NOTE - For continuity tests there is no need to rotate the megger handle at the above speed. Slow rotation will be sufficient.

   Note - In case of continuity test, if the test circuit is O.K. Megger will show zero or very low resistance. If there is no continuity the reading will be very high or infinity. In case of insulation test, if the test circuit is alright Megger will read infinity or in Megohms, otherwise low resistance or zero.

TABULAR RECORD OF OBSERVATION

Sl. No.	Test Between -	Guide sketch	Megger reading	REMARKS
1	Terminals A1-A2 B1-B2 C1-C2 of a 3-Ph Ind.Motor			
2	Terminals A1-B1 B1-C1 C1-A1 of a 3-Ph Ind. Motor			
3	Terminal A1 to body B1 to Body C1 to Body of the above motor			

Sl.No.	Test Between –	Guide Sketch	Megger reading	Remarks
4	the two terminals of the primary/ sec. winding of a S.ph. transformer			
5	one primary terminal and one secondary terminal of a S-Ph transformer			
6	Primary to core and secondary to core			
7	Earth pin of a 3-pin plug and the body of a portable Electric drill			
8	Earth pin and body of a flexible shaft Grinder–and between each of the remaining pins and body			

9 On the above lines test and Record the readings and results of some more electrical appliances and installation, (take guidance from the instructor).

PRECAUTIONS

1. Megger testing must be done only on an appliance or installation which is not energised.
2. Do not touch the Megger terminals or leads while rotating the handle.
3. Ensure Megger leads are properly connected and are in good condition.
4. While using double range Megger use ohms Range for continuity test and make sure to read the correct scale depending on the range selection.

QUESTIONS FOR EVALUATION

1. What type of voltage is produced in a Megger when handle is rotated (AC/DC)
2. What is the source of supply for testing, in a transistorised Megger?
3. If you have to test a 3-phase 400 V induction Motor what is the voltage of Megger that should be used?
4. While conducting the test between the armour of a cable and one of its core, the Megger shows 50 k.ohms. What is your conclusion about this cable ?
5. While conducting the continuity test on a transformer windings Megger always shows infinity. What is your conclusion about this test?
6. What will happen if you touch the terminals of the Megger when some one is rotating its handle?
7. State whether the following statements are true or false.

   a) Ohm Meter is used to measure the resistance

   b) Megger is used for testing insulation

resistance of installations and Electrical applicances.

c) The test voltage of a Megger commonly used is 250 volts.

d) Electricity Rules insists on using 1000 V Megger for testing medium voltage installations and Motors.

e) With no leads connected to the terminals, it will read zero if the handle is rotated.

f) Spring control in the Megger keeps the pointer in zero position when handle is not rotated.

g) We can use the Megger for measuring the current also.

h) Guard ring is used to protect the Megger from heavy current if there is any short circuit in a circuit under test.

i) Megger test should never be conducted on a live circuit.

j) Test voltage for a transistorised Megger is obtained by plugging it to the supply mains.

REFERENCES

1. Electrical Measurements and Measuring Instrument
E.W. Golding

2. Electrical Instruments and Measurements
Alexender

3. Electrical Engineering Vol.I
C.L.Dawes

EXPERIMENT/PRACTICAL: 3(a)

Construction and working of A C energy meters.

SPECIFIC OBJECTIVES

1. To learn the construction and working of an energy meter.
2. To connect a single-phase and a three phase energy meter to load.
3. To learn about energy meter errors and their rectification.

INTRODUCTORY INFORMATION AND RELATED THEORY

Energy meters are of induction type integrating instruments and are classified as (a) Single phase (b) Three Phase, three wire and (c) Three phase four wire. These are of current rating of 5,10,20,25,50 and 100 ampers and of voltage rating of 230/250 (single phase) and 400/440 V (Three phase). The meters used on 11 KV and above are connected through C.T. and P.T. Induction type single phase energy meter is commonly used for domestic purposes.

Electrical energy is defined as the product of power and time where power p = VI Cos θ

In the above equation V stands for voltage, I for current, t for time in seconds and Cos θ is the power factor. Therefore this instrument consists of (i) Voltage coil or pressure coil or potential coil or shunt coil to measure voltage (ii) current coil or series coil to serve current in the current. These coils are wound on soft iron pieces to form two electromagnets. One is known as series magnet (M1) and is excited by the line current and other as shunt magnet M2 which is excited by supply voltage. An aluminium disc Ad is kept between two magnets which is mounted on a vertical spindle.

A simplified line diagram illustrating the construction is shown in the figure 1a and 1-b. The brake magnet is made of a C shaped piece of alloy steel and exerts braking torque on the disc proportional to its speed of rotation.

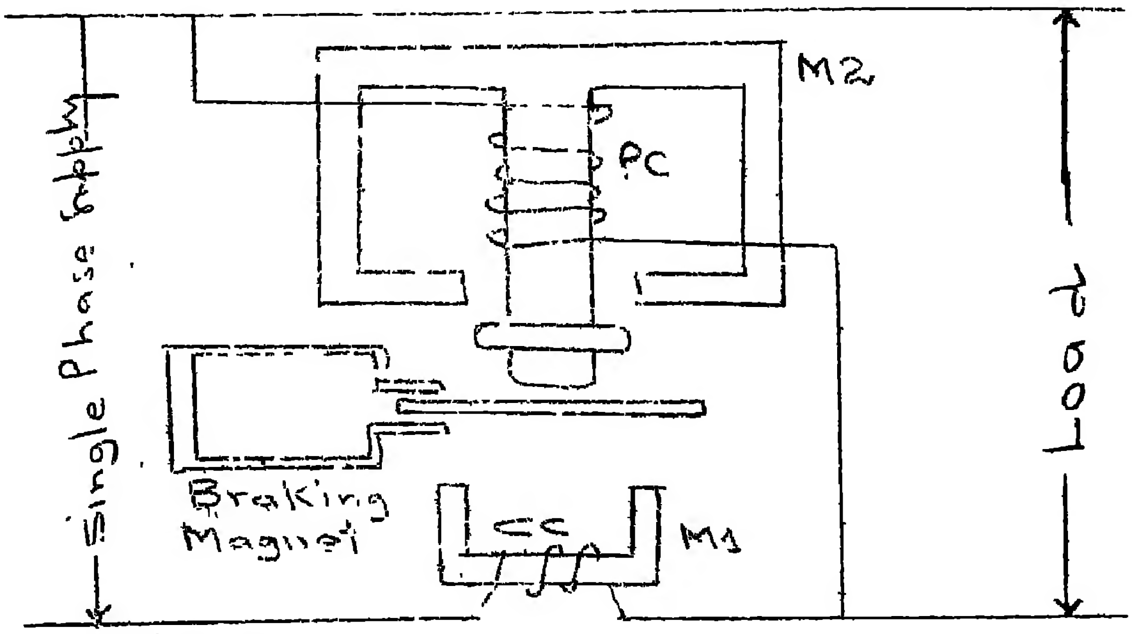


Fig. 1a.

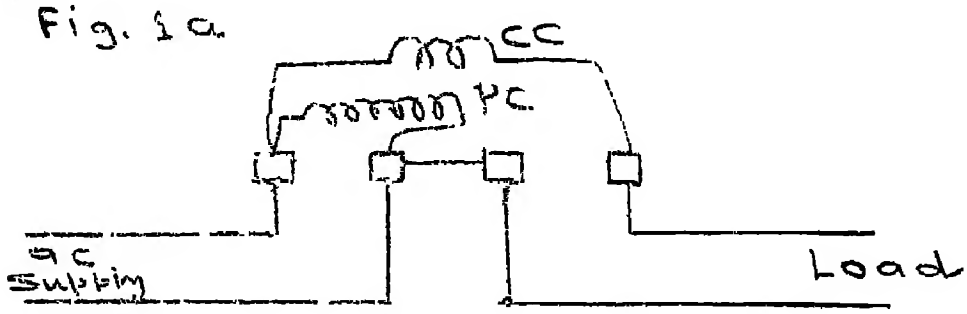


Fig. 1b

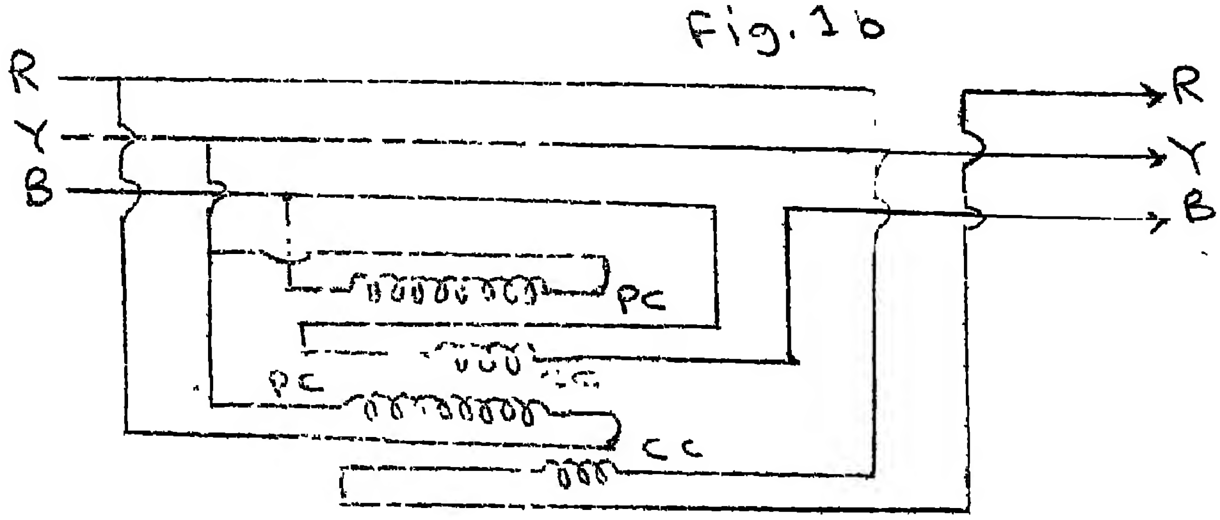
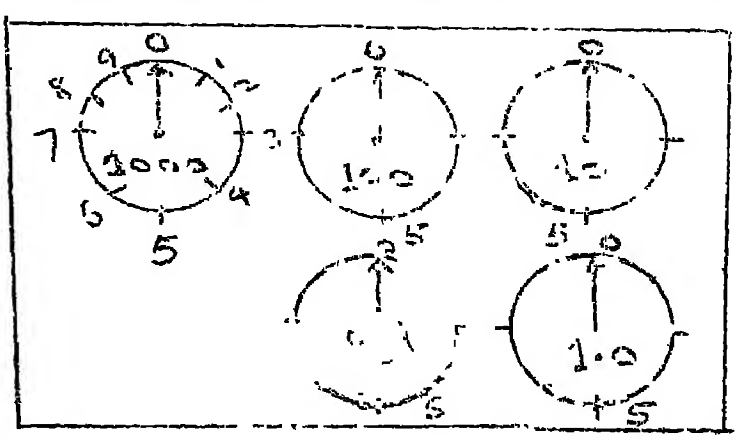


Fig. 3.

Working:-The flux ϕ_2 produced by magnet M2 is directly proportional to supply voltage V and lags behind it by 90^0. Exact phase displacement of 90^0 is achieved by copper shading bands (CSB), also known as power factor compensator or compensating loop. The flux ϕ_1 produced by series magnet M1 is directly proportional to line current I and is in phase with it. The two fluxes ϕ_1 and ϕ_2 act on disc and induce e.m.fs to result in eddy currents. The interaction between two fluxes and eddy currents result in the production of a rotating torque on the disc. This torque is proportional to the power consumed in the load and makes the disc rotate. When the rotating torque becomes equal to braking torque, the disc rotates at constant speed. The number of revolutions made in given time 't' by the disc therefore becomes proportional to the energy consumed in the circuit. During time 't' this energy is being recorded by means of a gear train. Nature of readings obtained on a energy meter are shown in fig.2.



The KWH indicated by pointers in fig.2 is 0038.4 kwh.

Fig. 2

Three Phase Energy Meter:

Three phase energy meters are combinations of two single phase energy meters in one unit. The basic principle employed is that of 2 wattmeter method of points measurement in a three phase circuit. Therefore in this energy meter, there are two pressure coils and

two current coils to be connected as shown in Fig.3. If the supply system is 4 wire, the neutral of supply is connected to load circuit directly or through a link provided for this purpose in the instrument.

Errors: The common effors that occur in Energy meter are as follows:

1. Load Error: Meter may run faster or slower than the requisite speed. The speed of the disc/may be adjusted by changing the position of brake-magnets.
2. Creep Error: On no load ordinarily meter should not run but sometimes the disc rotates very slowly due to incorrect friction compensation or over voltage of supply. This error is known as creeping error. To prevent it, a circular hole near the periphery is drilled in the rotating disc.
3. Power Error: Meter may have more than permissible error when running at 0.5 or other power factor loads. To correct it current flux in compensating coil is adjusted by adding the resistance in series with circuit.
4. Low Load Error: Meter may have error while running at light load. This is corrected by adjusting the position of copper shading Bands (CSB).

TABULAR RECORD OF OBSERVATION:

Sr.No.	Name of the part	Function of the part	Remark

QUESTIONS FOR EVALUATION

1. Distinghish between watt-meter and energy meter.
2. What is the difference between single phase and three phase energy meters.
3. What happens when induction type instrument is connected to D.C. supply ?
4. Distinguish between Indicating and Integrating meters. Give examples of each.
5. What are the practical units for power and energy ?
6. What is the relationship between power and energy ?

REFERENCE

1. Electrical Measurement - J.B. Gupta
2. Electrical Instruments and Measurements - Alexander.

EXPERIMENT/PRACTICAL NO: 3(b)

TITLE OF EXPERIMENT/PRACTICAL

To calibrate an energy meter.

SPECIFIC OBJECTIVES

1. To calibrate a single phase induction type energy-meter at various loads of unity power factor.

2. To determine the percentage error.

INTRODUCTORY INFORMATION AND RELATED THEORY

In the use of an energy-meter, it is important to know whether energymeter to be used is indicating correct energy or not. If it is not recording true energy then its percentage error is determined. The calibration of energy-meter is carried out to find the percentage error of the instrument. Most popular method of calibrating the energymeter is to compare it with or standard energy-meter. Testing of energy meter is done at full load, half full load of unity p.f. 0.5 power factor. If the standard energymeter is not available then a standard wattmeter along with a stop watch may be used. The circuit diagram is shown in Fig.1. The supply is switched-on for a certain time which is recorded with the help of a stop watch. The true energy is equal to the product of the readings of wattmeter and the time. The calculated energy is converted to kwh for the purpose of comparison. Observed energy is equal to the readings of the indicating pointers in kwh of the energy-meter under test.

$$\text{percentage error} = \frac{(\text{observed energy} - \text{true energy})}{\text{True energy}} \times 100$$

Permissible Errors:- As per I S 722 Part IV 1966 clause 10-6-2 Table 4, limits of errors permissible is listed as below:

% load	Power factor	Limits of errors in percent.
5	unity	+2.5 to-3.0
10 to 100	unity	+2.0 to-2.0
10	0.5 (lag)	+2.5 to-3.0
20 to 100	0.5 (lag)	+2.0 to-2.0

EQUIPMENT AND MATERIALS

1.	750 Watt Heater for load	2
2.	Lamp 60 Watt 250V	2
3.	D.P.I.C. Main Switch 15A/250 V	1
4.	MI Voltmeter 0-300V (Standard class A)	1
5.	Moving iron Ammeter 0-5 Amp.(standard class A).	1
6.	A.C. single phase energy-meter 5 Amps. 300 V	1
7.	Stop watch	1
8.	Single pole switch 5A/250 V	4

CIRCUIT DIAGRAM:

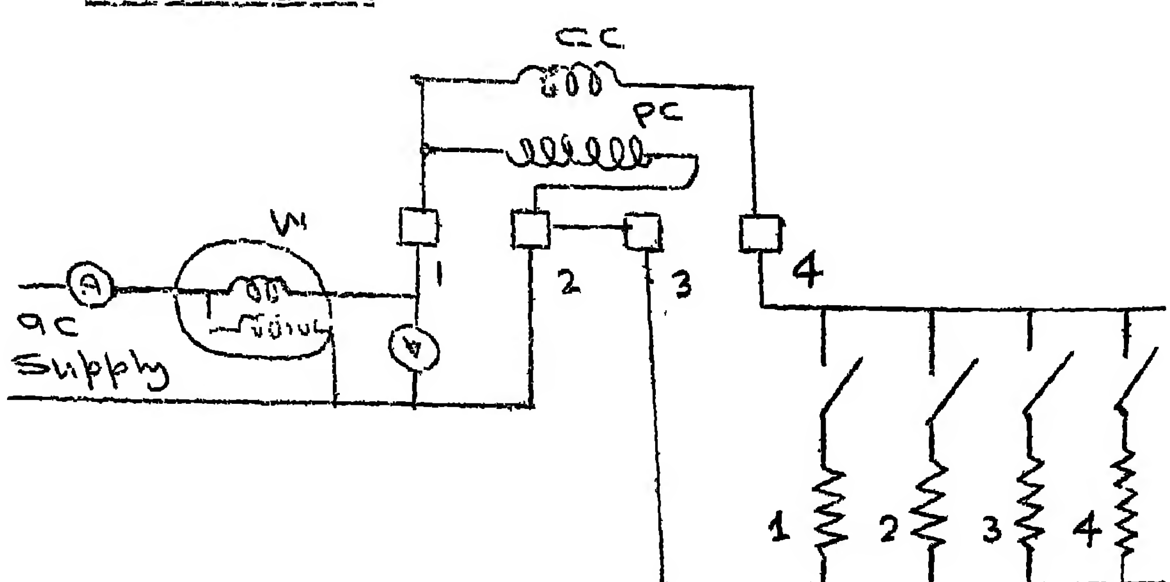


Fig.1.

PROCEDURE

1. Connect energy-meter, ammeter and Voltmeter, watt-meter through the switches as shown in fig. 3.
2. Energise the circuit through D.P.I.C. main switch.
3. Adjust the load to 1/4th of the rated value.
4. Record the reading of ammeter & volt-meter & wattmeter.
5. Count time for 10,20 revolutions of the disc.
6. Note the meter constant given on the meter cover (e.g. 400 Revs/KWH)

TABULAR RECORD OF OBSERVATION

Load	V volt	I amp.	Time for 10/20 revs of disc in second (t)	Calculated energy KWH = $\frac{Wxt}{1000x3600}$	Recorded energy =KWH	% error = $\frac{\text{Recorded energy} - \text{Calculated energy}}{\text{Calculated energy}} x100$
1/4						
1/2						
3/4						
1						

PRECAUTIONS

1. Record the stop watch reading carefully.
2. Count the number of revolution carefully while counting number of revolution always start from the red mark on the disc.

QUESTION FOR EVALUATION

1. By changing the position of brake magnet towards the spindle, with the speed of the disc increase or decrease ?

2. A 5 ampere, 230 volts energy meter on full load of unity p.f makes 60 revolution in 6 mts. If normal disc speed is 520 rev/kwh, what is the percentage error ?

3. A meter having a constant of 600 rev/kwh makes five revolution in 20 seconds. Calculate the load in kw.

Hint : -

$$\text{Energy consumed in 20 sec.} = \frac{\text{Number of rev. made}}{\text{Meter constant in rev/kwh}}$$

$$\text{Load in Kw} = \frac{\text{Energy consumed}}{\text{Time}}$$

REFERENCE

1. Electrical Technology - J.B. Gupta
2. Electrical Measurement and Measuring Instruments - Golding.
3. Experimental Electrical Engg. - D.T.A.Rapson

EXPERIMENT/PRACTICAL NO: 4

TITLE OF EXPERIMENT/PRACTICAL

Calculation of power factor in inductive circuit applying a.c. voltage.

SPECIFIC OBJECTIVES:

1. Measurement of power factor in a resistive circuit.
2. Measurement of power factor in an Inductive Circuit (i.e. When resistance and inductance are both connected in series).

INTRODUCTORY INFORMATION AND RELATED THEORY

An inductive circuit consists of a coil with or without an iron core having negligible resistance. Practically, the pure inductance does not exist as the inductive coil always has some small resistance. However a coil of thick copper wire wound on a laminated iron core having small resistance and high inductance is known as choke coil. Choke is commonly used for fluorescent tube.

Consider an a.c. circuit consisting of resistance R ohms and inductance of L Henry connected in series as shown in Fig.1. The voltage drop across resistance

$V_R = IR$

Voltage drop across inductance $V_L = I X_L$

where $X_L = WL$ known as inductive reactance and $w = 2\pi f$, Where "f" is the Frequency of the supply. V is the applied voltage being equal to the vectorial sum of V_R and V_L

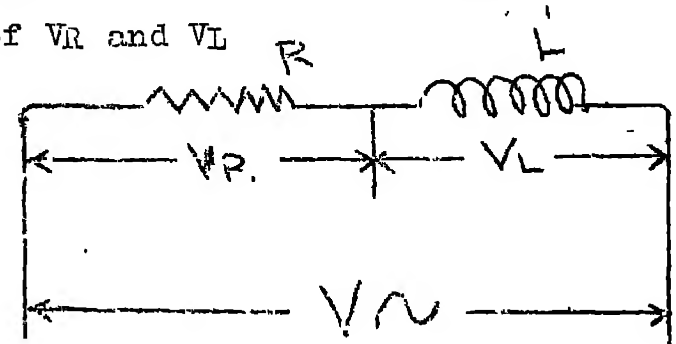


Fig.1

The magnitude of the applied voltage V $= \sqrt{(V_R)^2 + (V_L)^2}$

Where as V_R = IR and

so voltage $V = I\sqrt{R^2 + X_L^2}$

The quantity $\sqrt{R^2 + X_L^2}$ is known as impedance of the circuit and is denoted by Z

$$V = IZ$$

The power factor of the circuit Cos θ is given as $\cos\theta = \frac{IR}{IZ} = \frac{R}{Z}$

Power factor, may be defined as Cosine of the phase angle between the voltage and current.

Power consumed in the a.c. circuit is given as

$$P = VI \cos\theta$$

or the Power factor of the given circuit is Cos

$$\cos\theta = \frac{P}{VI}$$

EQUIPMENT AND MATERIALS

1.	Auto transformer	1
2.	M.I. Ammeter	1
3.	M.I. Voltmeter	1
4.	Wattmeter Electro-dynamometer type	1
5.	Known resistance	1
6.	Choke	1
7.	Two way Switch	1

CIRCUIT DIAGRAM

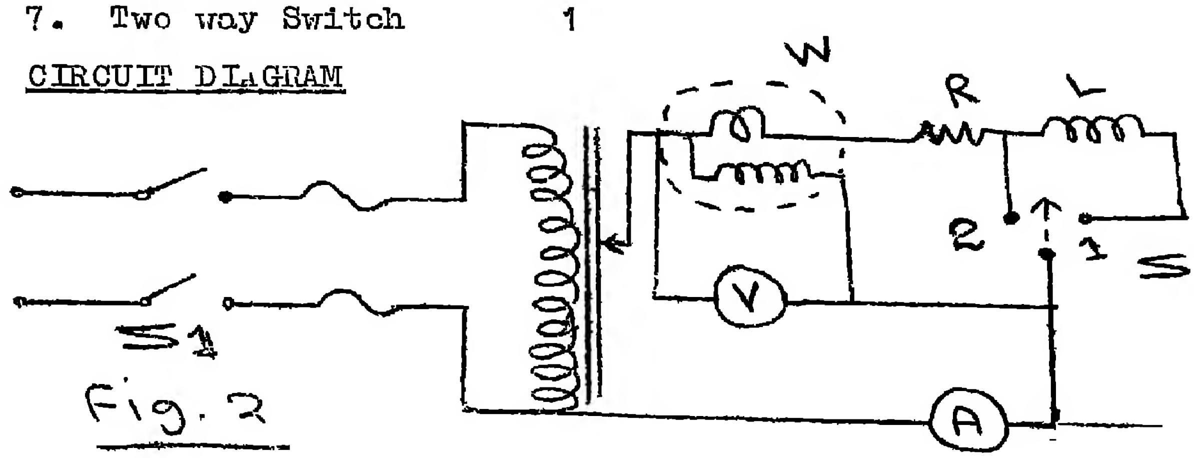


Fig. 2

PROCEDURE

1. Connect a fixed resistance R in series with Choke of small resistance.
2. Connect Wattmeter (W), Voltmeter (V) and Ammeter (A) in the circuit as shown in fig. 2.
3. Keep the setting of auto transformer at minimum position.
4. Close the main switch (S_1) and put two ways Switch 'S' at position '1'. In this case Choke and resistance will be in series.
5. Note the readings of ammeter, Voltmeter and wattmeter by changing the position of autotransformer.
6. Put two way switch S at position '2'. after putting auto transformer in minimum position. Now only R is in the circuit.
7. Repeat (5)
8. Note the reading V_2 W_2 & I_2

TABULAR RECORD OF OBSERVATION

Sr. No.	Inductive Circuit (Switch in position 1)			Pure resistive Circuit (Switch in position 2)			
	Ammeter reading in Amps (I_1)	Voltmeter reading in volts (V_1)	Wattmeter reading in watts (W_1)	Ammeter reading in amps I_2	Voltmeter reading in volts V_2	Wattmeter reading in watts W_2	Power factor $= \frac{W_2}{V_2 I_2}$

PRECAUTIONS

1. Note the readings of the instruments after removing parallax
2. Always check the connections before energising the circuit.
3. If the needle of wattmeter read backwards then reverse the pressure coil or current coil connections.

QUESTIONS FOR EVALUATION

1. What is power factor ? State its importance in A.C. circuits.
2. What is the relationship between the current and voltage in R.L series circuit ?
3. Explain what is meant by impedance in an a.c. circuit.
4. What is the effect of supply frequency on R-L series circuit ?
5. What is the unit of the power factor ?
6. Can power factor be greater than unity ?
7. Write down the expression of power for
   (i) a.c. system (ii) d.c. system

REFERENCE

1. Electrical Engineering Experiments - U.M.A Bhatnagar

EXPERIMENT/PRACTICAL No. 5

TITLE OF EXPERIMENT/PRACTICAL

To Study connections and voltage and current relationship in star/delta combination of resistances.

SPECIFIC OBJECTIVES

1. Connection of 3-equal resistances in star and delta.
2. Measurement of phase voltage and line voltage in star and delta circuits using 3-phase supply.
3. Measurement of phase current and line current in star and delta circuits using 3-phase supply.

INTRODUCTORY INFORMATION AND RELATED THEORY

The three phase windings may be connected in the following two ways:

(a) Star (Y) or wye

(b) Delta (Δ) or Mesh

Each winding has two terminals, one starting and another finishing. As shown in fig.1, the starting terminals are markd 1,2,3 and finishing terminals are markd 1', 2', 3'

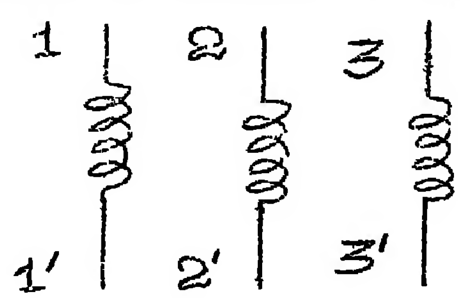


Fig.1 Three coils showing start and finish points

These windings may be connected in star as represented in fig 2(a) and 2(b) or in delta as represented in fig 3(a) and 3(b).

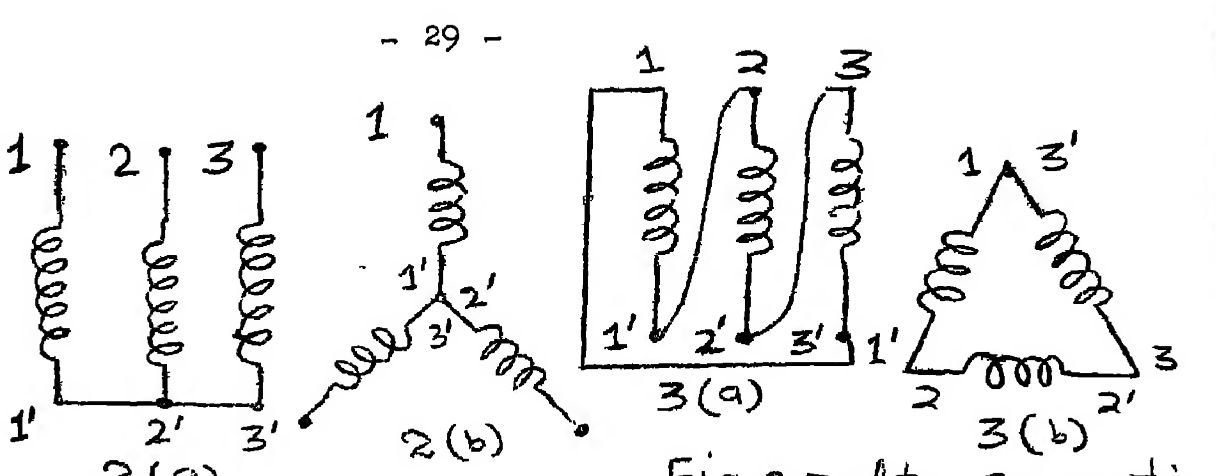


Fig. 2. Star Connection Fig. 3 Delta Connection

(a) Star Connection

The common point in star connection, at which either the starting or the finishing ends are joined together, is called neutral or star point. The voltage between any line and neutral point i.e., voltage across the phase winding is known as the phase voltage while the voltage between any two lines is known as the line voltage as indicated in fig. 4.

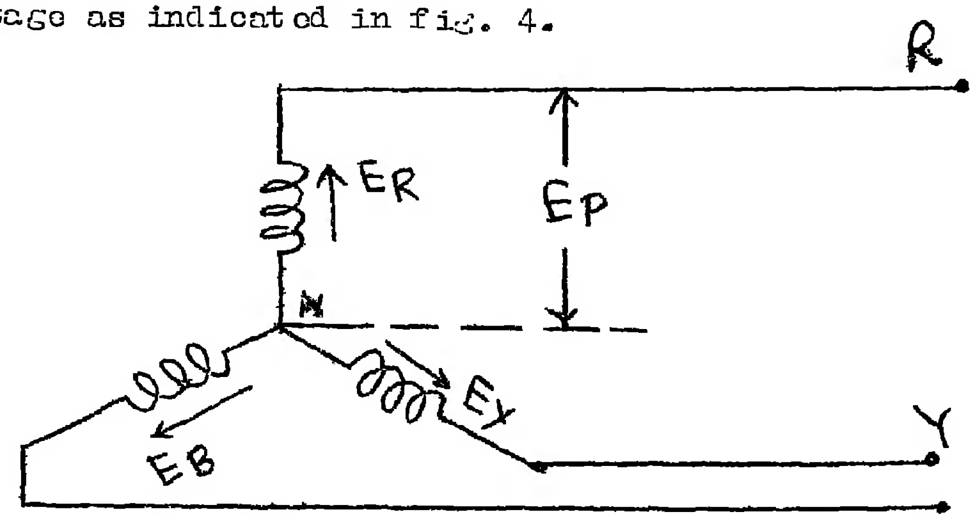


Fig. 4

Line and phase voltages and currents in star connection

In star connection the relation between line and phase values of voltages and currents is given by $E_L = \sqrt{3}\ E_p$

$I_L = I_p$

Where E_L and I_L are the line voltage and line current E_p and I_p are the phase voltage and phase current respectively.

(b) Delta Connection

When the starting end of one coil is connected to finishing end of another coil as shown in fig.3, the delta connection is obtained. The relation between line and phase values of voltage and current are given by

$$E_L = E_p \quad ; \quad I_L = \sqrt{3}\, I_p$$

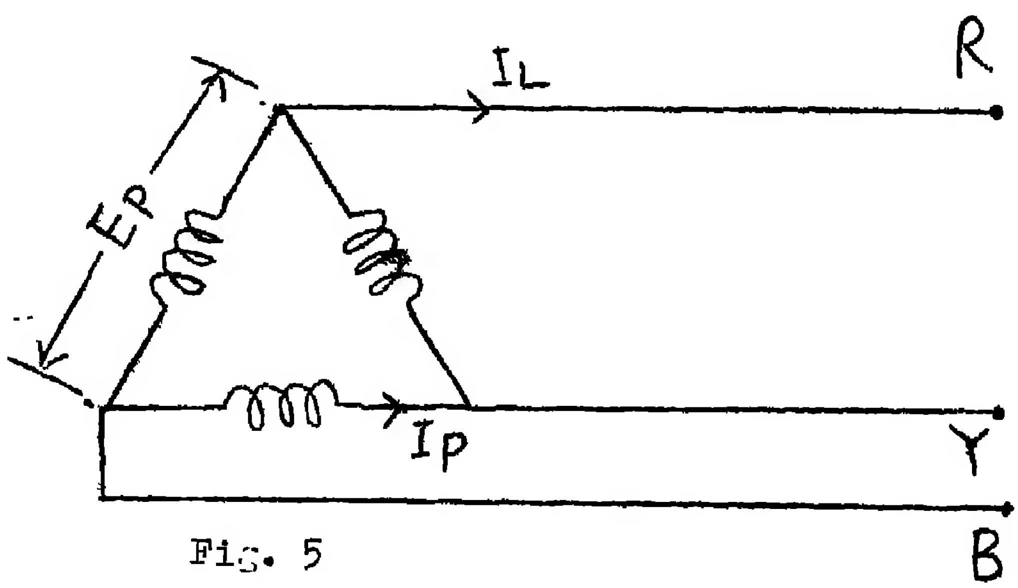


Fig. 5

Line and Phase voltages and currents in delta connections.

Power in 3 phase circuit both for star and delta is given by:

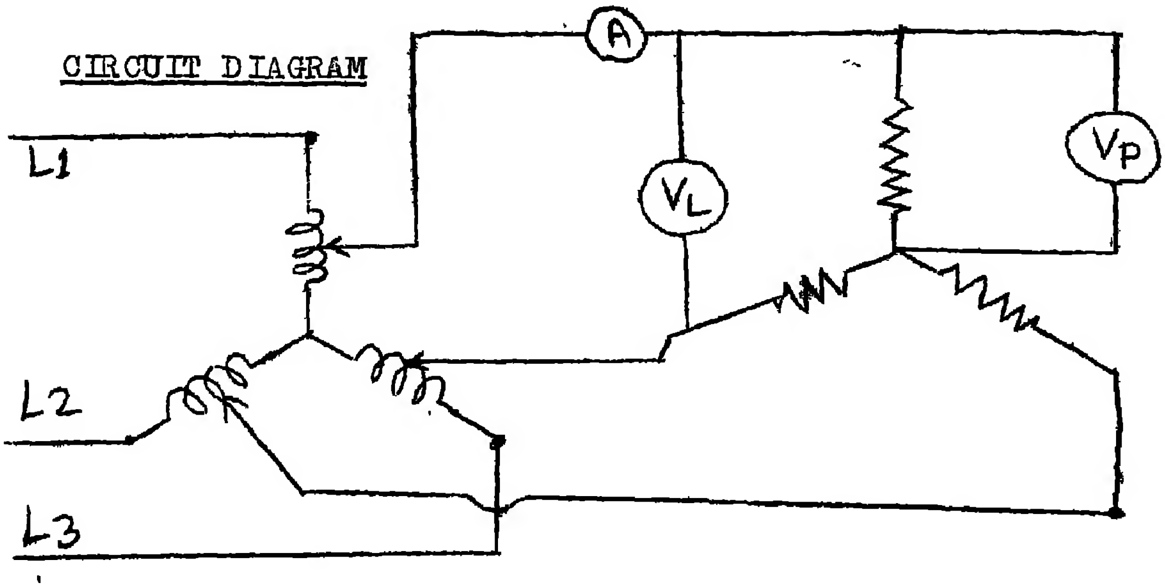
(i) in terms of line values $P = \sqrt{3}\, E_L I_L \cos\theta$

(ii) in terms of phase values $P = 3\, E_p I_p \cos\theta$

EQUIPMENT AND MATERIALS

1.	Similar resistances of equal rating	3 Nos.
2.	Ammeter M.I type	2 Nos.
3.	Voltmeter M.I. type	2 Nos.
4.	Variable ratio Auto transformer	

CIRCUIT DIAGRAM



3 Phase Auto transformer

Fig.6 Measurement of Line and phase voltages and Currents in star connected resistances.

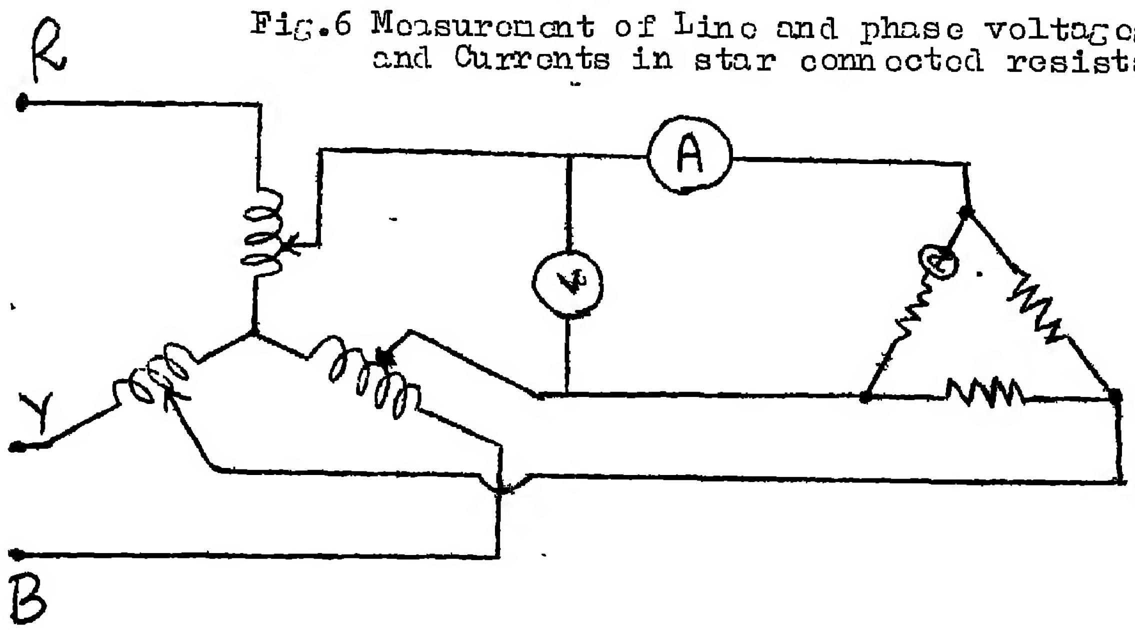


Fig. 7 Circuit diagram-measurement of line and phase voltages and currents in delta connected resistances.

PROCEDURE

1. Connect the three resistances in star.
2. Make the connections as showin in fig. 6
3. Adjust the auto transformer to zero position. close the switch S_1
4. Increase the voltage gradually, keeping a watch on ammeter so that the current does not exceed the rated value of the resistances.
5. Record several sets of readings of voltmeters and ammeters.

6. Adjust the auto-transformer back to zero position. Open the switch S_1.
7. Connect the resistances in delta.
8. Make the connections as shown in fig. 7
9. Repeat steps (5) to (6).

TABULAR RECORD OF OBSERVATIONS

Table 1 Star Connections

S.N.	V_L	V_p	I_L	V_L/V_p	Remarks

Table II Delta connection

S.N.	V_L	V_p	I_L	I_p	I_L/I_p	Remarks

PRECAUTIONS

1. Always adjust the auto-transformer at zero position before closing the switch.
2. While adjusting the auto-transformer keep a close watch on the ammeter, indicating the phase current so that the current flowing through the resistances does not exceed their rated value.

QUESTIONS FOR EVALUATION

1. What is the difference between 3 phase star and delta connections ?

2. What is meant by the neutral point ?

3. If three given resistances are connected once in star and then in delta. The combination in each case is connected across 200 V. In which case the current flowing through individual resistances will be more ? Also justify your answer.

REFERENCES

1. Electrical Technology - H. Cotton

EXPERIMENT/PRACTICAL: 6

TITLE OF EXPERIMENT/PRACTICAL

Construction of a Small transformer

SPECIFIC OBJECTIVES

To construct a small transformer for 230/18-12-6 Volts.

INTRODUCTORY INFORMATION AND RELATED THEORY

Transformer is a static device which transforms A.C voltage from one value to the other at the same frequency. It consists of two coil windings on a core made of magnetic material. A.C. Voltage is applied to one of the coils which is called primary. The other coil from which output is taken is known as secondary.

A transformer is represented diagram-atically in Fig1

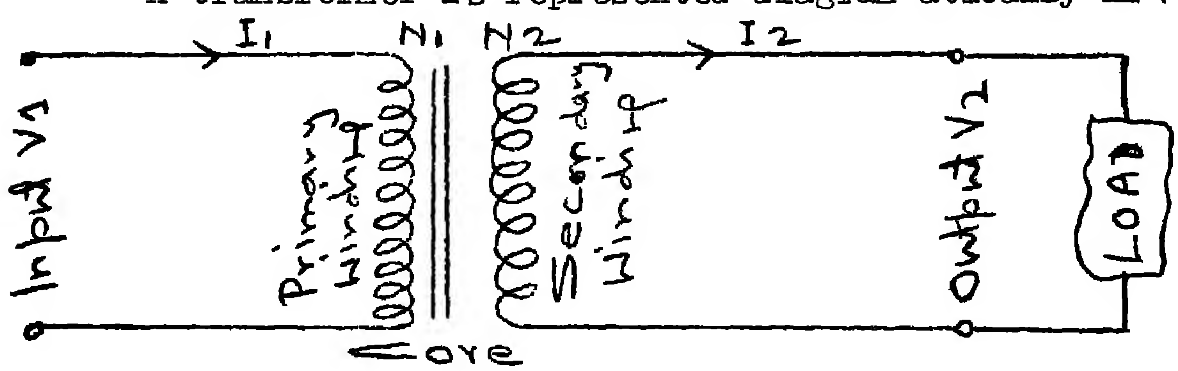


Fig. 1

Diagramatic representation of transformer

The relation between primary and secondary voltages (V_1, V_2), currents (I_1, I_2), Number of turns (N_1,N_2) respectively is given by

$$\frac{V_2}{V_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1}$$

The ration $\frac{N_2}{N_1}$ is known as transformation ratio K. If the secondary voltage (V_2) is more than the primary voltage (V_1); then it is known as a step-up transformer. If Secondary voltage is less than primary voltage then it is called a step down transfermer.

(A) CORE:

As a.c. is applied on the primary winding therefore, the flux flowing through the core is alternating. To reduce the eddy current loss, the core is made of laminations. Thickness of laminations or stampings varies from 0.35 mm. to 0.55 mm. The laminations are insulated from each other by a thin coat of insulating varnish. For good magnetic characteristics, cold rolled silicon steel is used. Silicon content may be of the order of 3 to 4%.

There are two types of transformers from construction point of view.

CORE TYPE: In this type the iron core surrounds the windings as shown in fig. 2(a) amd 2(b).

SHELL TYPE: In this type the iron core surrounds the windings as shown in fig. 3(a) and 3(b).

Various types of laminations and stampings are shown in fig. 4,5 & 6. In fig. 4(a) and 4(b), two L shaped laminations are shown indicating their mode of placement in the alternate layers. They are placed together to give rectangular formation of core. The complete laminated core consists of rectangular laminations placed alternately one over the other as shown in fig 4(c), so that the joints are staggered. The joints are staggered to avoid continuous air gap which increases the magnetising current. Further, if the joints are not staggered the core will have less mechanical strength and during operation there would be an undue humming noise.

The core could also be assembled out of U & I types of laminations as shown in fig. 5(a) and 5(b). The L and U-I laminations are generally used for core type transformer. For making shell type transformer generally the combination of U,T laminations is used as shown in fig.6(a) and 6(b).

<u>WINDING</u>:- In case of small transformers, coils are usually wound with round wire in the form of a bobbin, in the same way as cotton thread is wound on a spool.

For small transformers of low voltage such as 230 V, about 5 to 8 turns per volt may be taken for primary winding depending on the size of the transformer. Secondary No. of turns can be obtained by the relationship.

$$N_2 = \frac{V_2}{V_1} \times N_1$$

The primary current can be calculated with the help of given volt-ampere rating of the transformer.

$$\text{Primary current } I_1 = \frac{\text{Volt-ampere rating}}{V_1}$$

Secondary current I_2 can be calculated from the relation

$$I_2 = \frac{N_1}{N_2} \cdot I_1$$

area of the Cross section of the winding conductor depends upon the current. Normally the size of the primary and secondary conductors will be different. To select the cross sectional size of the winding conductor tables of the manufacturers may be consulted. Normally the current density of 3 amp. per sq.mm. may be assumed for determining the size of the conductor.

EQUIPMENT AND MATERIALS

1. Stampings/Laminations
2. Malinex insulating sheet
3. Thin insulating paper.
4. Plastic or backlite former
5. Small bolts and nuts for clamping the stampings.
6. Super enemelled copper winding wire.
7. Cotton tape and empire tape.

CIRCUIT DIAGRAM

Diagrams showing details of the core are given in fig.4,5 and 6. Fig.2(a) and 2(b) show the constructional details of core type transformer and fig.3(a), and 3(b) give the details of shell type transformer.

PROCEDURE

1. Select the size of the core and the type of stampings.
2. Select suitable size of the conductor for windings as explained above.
3. Select/make a former of suitable size.
4. Wrap the former with malinex insulation sheet.
5. Wind the primary winding on the former preferrably with the help of winding machine.
6. After every 2 or 3 layers of primary winding use a layer of thin insulating paper.
7. After completing the primary winding, wrap with melinex sheet.
8. Wind the secondary turns.
9. Bring out taps at suitable number of turns for 6, 12, 18 volts.
10. Wrap with empire tape or cotton tape for insulation and mechanical protection.

11. For a core type transformer two such windings, each consisting of half the total no. of turns, are made on two formers. Both the legs of transformer will thus have half the number of turns of each winding.

12. Assemble the core withwinding as shown in fig.2 & 3.

13. Clamp/bolt the core.

TABULAR RECORD OF OBSERVATION

TABLE - 1 CORE

Types of stampings used.	Total No. of stampings	Dimensions of Core		
		Cross-section (mm^2)	Height (mm)	Breadth (mm)

TABLE 2

Winding	Voltage(Volts)		No. of turns	Current (Amp)	Size of wire (mm)
	Designed value	Actual measured value			
Primary					
Secondary					

PRECAUTIONS

While winding, the enamel wire should not come in contact with sharp metallic edges.

QUESTIONS FOR EVALUATIONS

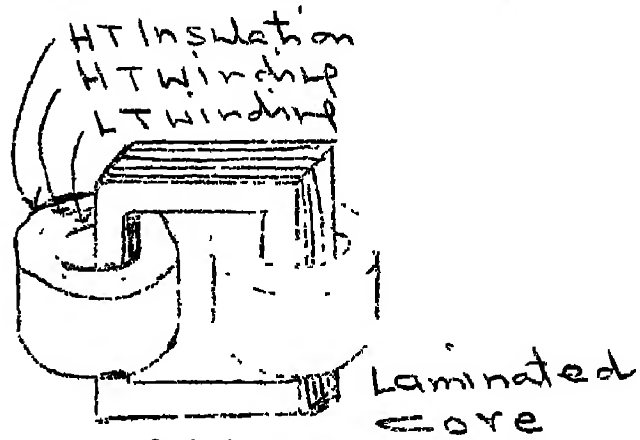
1. What is the function of a transformer ?
2. What is meant by step-up and step-down transformer ?
3. What is the function of the Core in a transformer ?
4. What material is used for the construction of the

transformer core ?

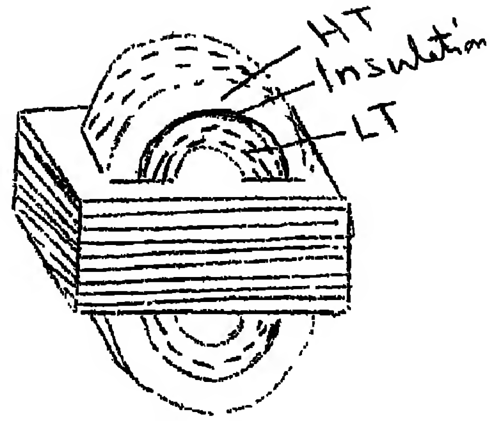
5. What is the difference between a shell type and core type transformers ?

REFERENCES

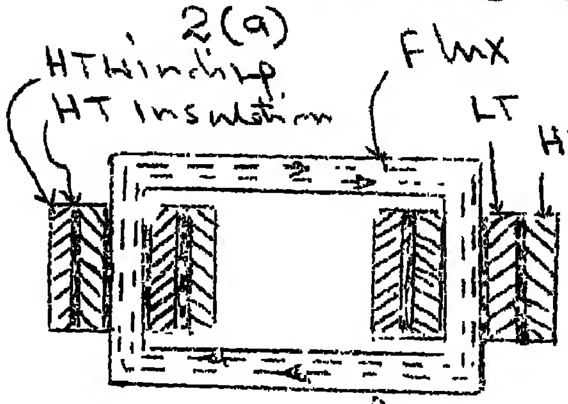
Electrical Technology by H. Cotton



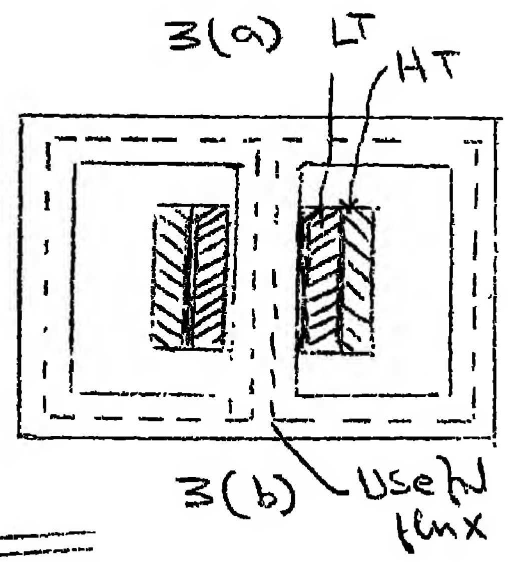
2(a)



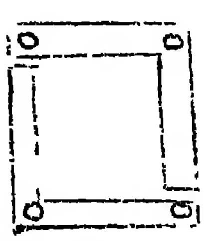
3(a)



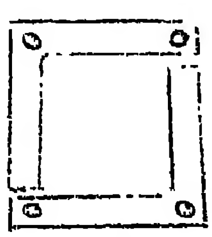
2(b)



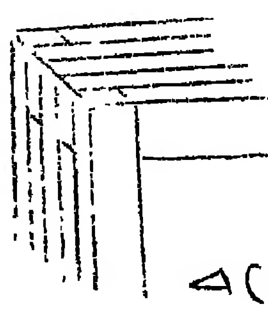
3(b)



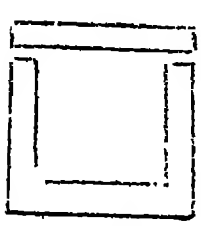
4(a)



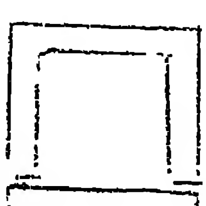
4(b)



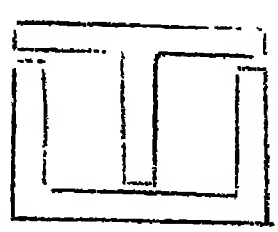
4(c)



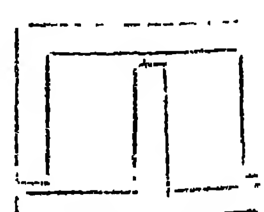
5(a)



5(b)



6(A)



6(B)

EXPERIMENT/PRACTICAL No. 7

TITLE OF EXPERIMENT/PRACTICAL

Measurement of losses and calculation of efficiency of transformers.

SPECIFIC OBJECTIVES

1. To measure iron and copper losses
2. To calculate the efficiency of a transformer at various loads and power factors.

INTRODUCTORY INFORMATION AND RELATED THEORY:

EFFICIENCY

The various losses in a transformer are:

1. Core losses
   (a) Hysteresis loss
   (b) Eddy current loss
2. Copper losses.

The iron losses of a transformer depend upon the frequency of the flux and (ii) its maximum value. Thus if the given transformer is operated at rated voltage and rated frequency, the iron losses remain constant. These losses are therefore classified as constant losses.

The copper losses are dependent upon the load current and are proportional to the square of the load current.

$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}} = \frac{\text{Power output}}{\text{Power output} + \text{losses}}$$

$$= \frac{V\ I\ \text{Cos}}{V\ I\ \text{Cos} + \text{core loss} + \text{copper loss}}$$

For measuring the core loss and copper loss, open circuit and short circuit tests are respectively conducted.

EXPERIMENTAL DETAILS

(a) Open Circuit Test:- The secondary winding is kept open and rated A.C. voltage is applied to the primary. The transformer draws small current of the order of 5% of the full load value. As the current is very small, the copper losses which are proportional to square of the current become negligible. Hence the power drawn by the transformer is only due to core losses(also called iron losses).

The suitable range of the ammeter used may be of the order of 15% of rated current of the transformer. The pressure coil of the wattmeter should be rated for about 25% more voltage than the rated value and current coil rated for about 15% of rated current.

The test is performed at rated value of the primary voltage, which may not always be available directly from the supply. For adjustment of the voltage, primary of the transformer is fed through a variable auto-transformer which is known by commercial names such as variac, Dimmerstat, etc.

(b) Short Circuit Test: - The short circuit test gives copper losses. The secondary terminals are short circuited by a thick wire. Starting from zero value, voltage is gradually applied on the primary winding. The voltage is adjusted till the rated current flows through the primary winding. This voltage is usually of the order of 6 to 10% of the rated value. As the voltage required for this test is very small, as compared to rated value, the flux is also very low. Therefore, the iron losses become negligible and the power consumed by the transformer in short circuit test is due to copper losses.

The suitable range of the ammeter may be of the order of 15% of the rated full load current. The current coil of the wattmeter may be of the above range and its pressure coil may be rated for about 20% of the rated voltage of the transformer.

EQUIPMENT AND MATERIALS

1.	Variable auto-transformer	1 No.
2.	Ammeter M.I.type	2 Nos.
3.	Voltmeter M.I type	2 Nos.
4.	Wattmeter Dynamometer type	2 Nos.

CIRCUIT DIAGRAM

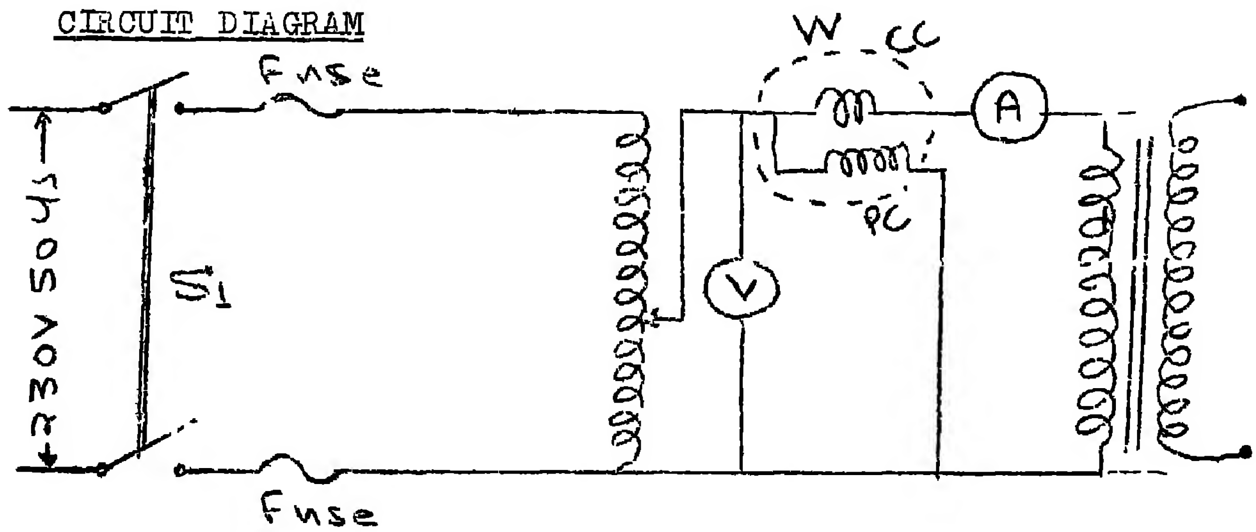


Fig-1(Connection for o.c. test)

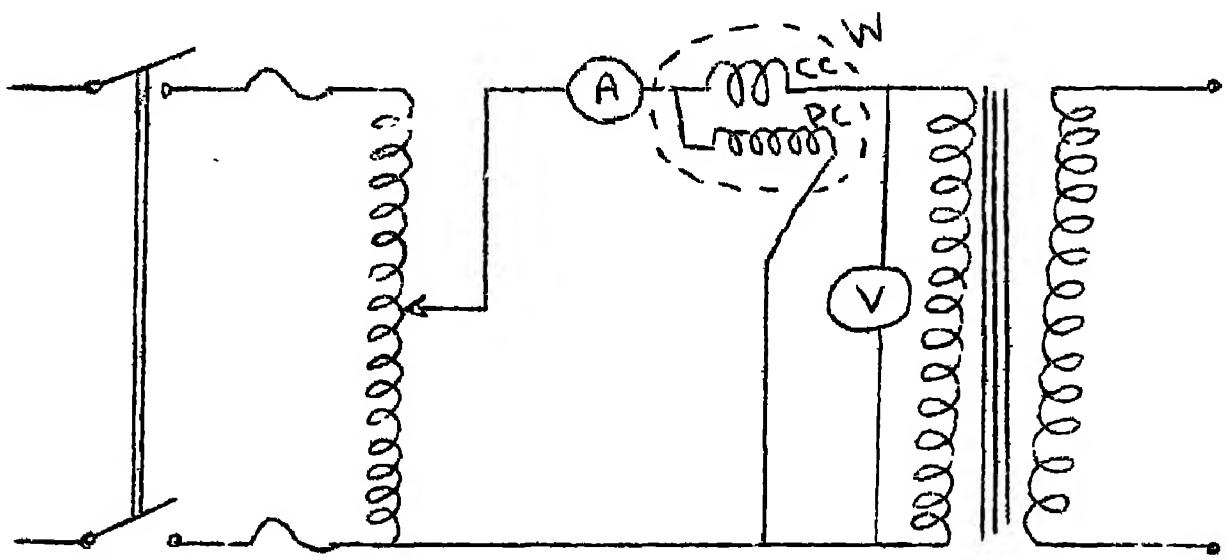


Fig.2 (Connection for S.C.test)

PROCEDURE

(a) O.C. Test:

i) Connect as shown in fig. 1

ii) Set the output voltage of the auto-transformer at zero. Close the switch S_1.

iii) Gradually and slowly increase the voltage applied to the primary. Adjust the voltage equal to the rated value.

iv) Record the wattmeter, voltmeter and ammeter readings.

v) Adjust auto-transformer back to zero voltage, open switch S_1

(b) S.C. Test

i) Connect as shown in fig. 2

ii) Strictly set the output voltage of the auto-transformer at zero. Close the switch S_2.

iii) Gradually and slowly increase the voltage applied. Keep a watch on the ammeter. Adjust the applied voltage such that the input current is very nearly equal to the primary rated current. Record the ammeter, voltmeter and wattmeter reading

iv) Repeat step 3, for values of applied voltage such that the input current are adjusted for various values between 80% to 125%.

v) Adjust auto transformer back to zero voltage. Open switch S_2.

TABULAR RECORD OF OBSERVATION

(a) O.C. Test

S.No.	Valtmeter reading V_1	Ammeter reading I_1	Wattmeter reading W_1

(b) S.C. Test

S.No.	Voltmeter reading V_2	Ammeter reading I_2	Wattmeter reading W_2	

Calculations

Iron loss = W_1

full load copper loss = W_2

Let current at given load = I

rated current at full load = I_{FL}

Efficiency at the given load

$$= \frac{V\ I\ Cos}{V\ I\ Cos + W_1 + W_2 \left(\frac{I}{I_{FL}}\right)^2}$$

PRECAUTIONS

1. Always adjust the auto transformer to zero position before switching on the supply.
2. Increase the applied voltage slowly and gradually.

QUESTIONA FOR EVALUATION

1. Name the different losses in a transformer.
2. How do the various losses vary with load ?
3. Why the efficiency of a transformer is much higher than the other electrical machines ?
3. Why do we neglect the copper losses in o.c. test ?
4. Why do we neglect iron losses in S.C. test ?

REFERENCE

A laboratory course in electrical machines - D.R. Kohli and S.K. Jain

New Chand & Prothers, Civil Lines, Roorkee(U.P)

EXPERIMENT/PRACTICAL NO. 8

TITLE OF THE EXPERIMENT/PRACTICAL

To change the oil of a transformer.

SPECIFIC OBJECTIVES

1. To understand the need of oil in a transformer.
2. To be able to understand the reasons for changing the oil in a transformer.
3. To be able to change the oil of a transformer

INTRODUCTORY INFORMATION AND RELATED THEORY

(1) The oil is used in a transformer to cool the transformer core and windings (2) strengthen insulation between the two windings and between turns of the winding.

The core and two windings of the transformer are placed in a tank filled with oil. The oil used in the transformer is mineral oil free of the moisture content. If the moisture contents increase beyond a certain limit, the insulation properties (break down strength) of the oil decreases appreciably. This contaminated oil is purified by heating and passing it through filters and centrefuger. It is essential to inspect oil of a transformer periodically but at least once in a year throughout the life of the transformer More frequent inspection may be necessary in some circumstances.

Oil Sampling in the Field

Samples of oil should be taken from the sampling valve, which is provided at the bottom of transformer tank. The sample should be collected in a properly cleaned (with gasoline) glass tube with tight stopper. The sample taken should be at least 500 gms. The sample should be drawn while the transformer is still hot from recent loading and oil is in circulation.

The sample should be visually inspected, if the sample is not clear, then it indicates presence of moisture. Any sludge present in the sample should be noted. If the sample is of dark colour then either it is highly contaminated with bituminous compound or it has suffered excessive oxidation. If the sample gives strong acid smell then the presence of acids is indicated which can corrode the transformer tank particularly if the oil also contains moisture.

Testing of Dielectric Strength

The container of the testing equipment should be properly rinsed with a portion of oil to be tested. The oil to be tested is filled in the container. Three minutes should be allowed so that air bubles etc. can escape. High voltage is applied and it is increased @ 3 KV per second. The value of breakdown voltage should be noted. The test should be repeated five times each filling and then the container of the testing equipment should be emptied. Fresh sample of the oil is again filled in the container and test repeated. The test is to be done for three fillings and the average of these 15 readings of breakdown voltage is usually taken as dielectric strength of the oil. If the equipment uses 2.54 cm. diameter square edged-electrodes spaced 0.254 cm apart then the condition of sample of the oil can be determined by the following table :

Average KV applied	Condition of oil
30 or above	Good
26 to 29	Usable
under 26	Poor

If the oil found is not good, then it should be filtered to remove impurities and moisture. The oil is removed from one tank and discharged into another. The oil withdrawn from the bottom of the tank is heated in oil heater, water content in the oil is absorbed by the absorber and it is filtered in the filter. The filtered oil is discharged to the tank with the help of lifting pump. Before the transformer is filled with oil, all accessories such as valves, gauges, thermometers, plugs must be fitted to the transformer and made oil tight. The whole cycle of operation has been illustrated in fig (1).

EQUIPMENT AND MATERIALS

1. Oil filled transformer
2. Metallic or synthetic rubber hose.
3. Oil heater
4. Moisture Absorber
5. Filter
6. Glass tube fitted with tight stopper.
7. Lifting pump.
8. Dielectric testing equipment

CIRCUIT DIAGRAM

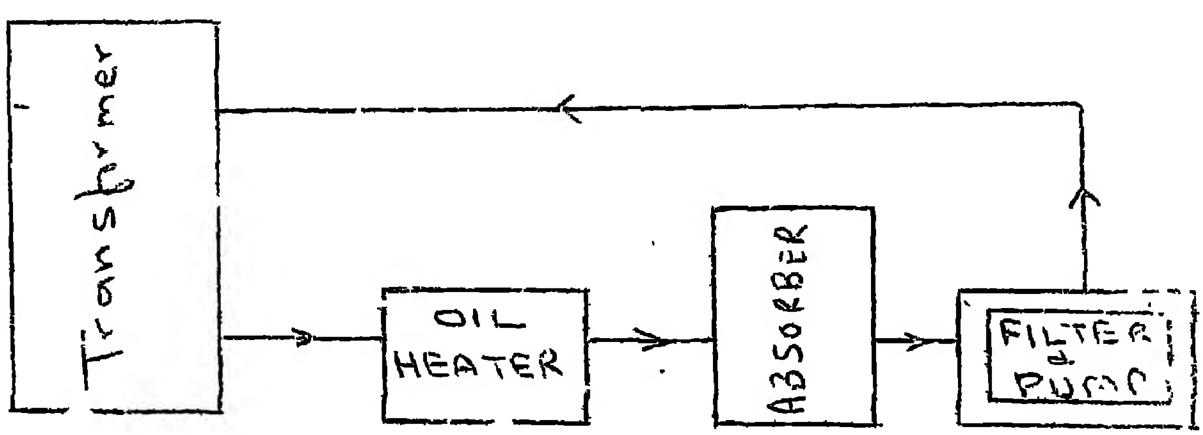


Fig.1

PROCEDURE

Take the sample of oil from the transformer in a glass-tube fitted with tight stopper. Rinse the dielectric testing equipment-container with the oil (typical fig. of Dielectric Testing Equipment is shown in fig. (2). Fill the oil in the container. Increase the potential difference between the two electrods gradually till a spark over/flash over takes place. Repeate the above test five times and then throw away this oil and refill the glass container of the Dielectric Testing Equipment with the sample oil and note down five readings of break down voltage. In this way obtain 15 readings of break down voltage for three fillings.

If the average break down voltage is less than 26 KV then the oil is passed through oil heater, moisture absorber and a filter. Filtered oil is discharged to the tank with the help of lifting pump.

TABULAR RECORD OF OBSERVATION

	Breakdown voltage K.V.
First filling	(i) (ii) (iii) (iv) (v)
Second filling	(i) (ii) (iii) (iv) (v)
Third filling	(i) (ii) (iii) (iv) (v)
	Average breakdown voltage = KV

PRECAUTIONS

1. Use glass tube fitted with air tight stopper.
2. In testing of Dielectric strength of oil increase the applied voltage gradually.

QUESTIONS FOR EVALUATION

1. Define Dielectric strength of oil ?
2. What happens when oil contains moisture ?
3. What do you mean by breakdown voltage of oil ?
4. Why do we use mineral oil in the transformer ?
5. What is the periodicity of inspection of transformer oil ?

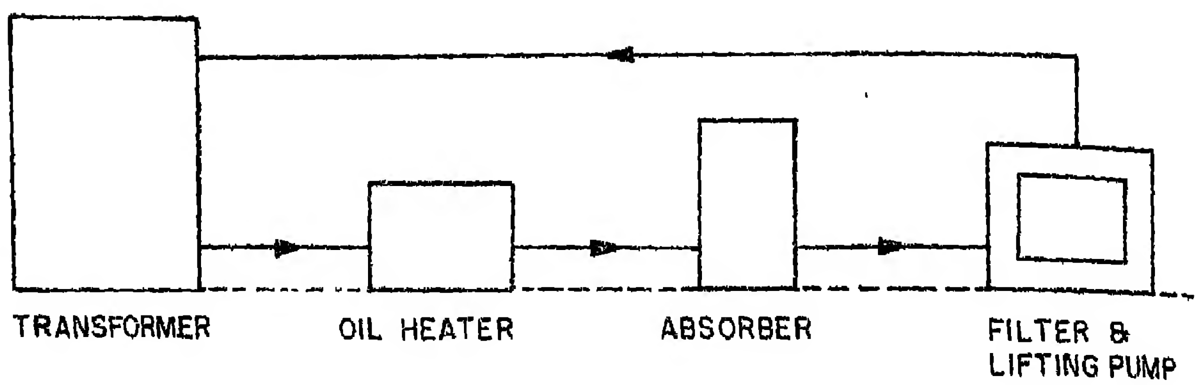

TRANSFORMER
OIL HEATER
ABSORBER
FILTER &
LIFTING PUMP

Fig 8·1

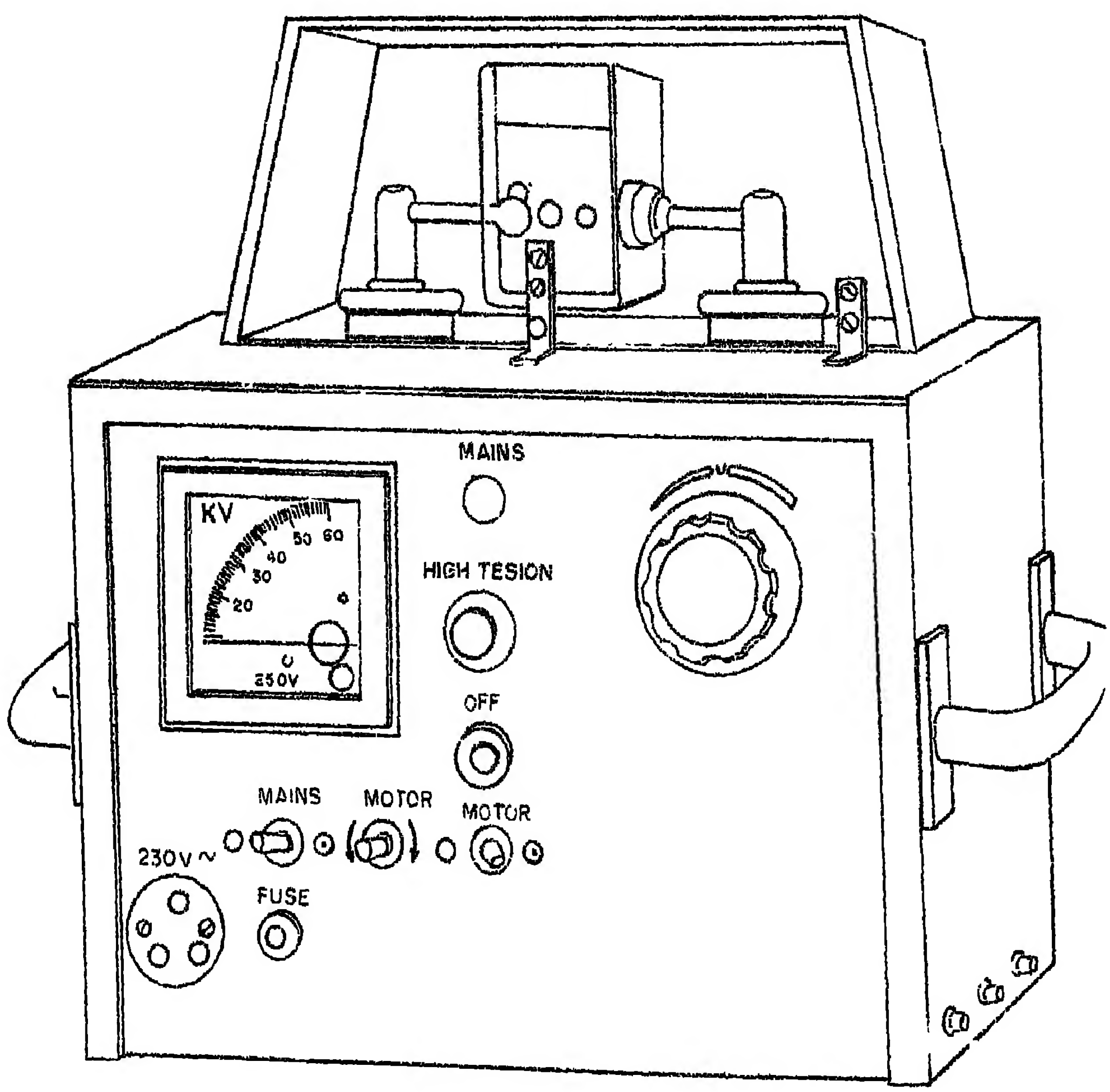

MAINS
KV
20
30
40
50
60
250V
HIGH TESION
OFF
MAINS
MOTOR
MOTOR
230V ~
FUSE

Fig 8·2

EXPERIMENT/PRACTICAL NO: 9

TITLE OF EXPERIMENT/PRACTICAL :

To study the use of instrument transformer

SPECIFIC OBJECTIVES

1. To get familiar with the use of instrument transformers.
2. To understand the basic difference between instrument transformers and other transformers
3. To connect instrument transformers

INTRODUCTORY INFORMATION AND RELATED THEORY:

Instrument transformers are used for (a) measuring large values of currents and voltages with the help of standard switch board ammeters and voltmeters of low ranges and (b) feeding supply to the protective relays. By use of instrument transformers (i) isolation and protection of operator is provided (ii) indicating instruments can be located at some distance from the circuit.

Basically instruments transformers are of two types:

(i) Current transformers (C.T.)

(ii)Potential transformers (P.T)

Instrument current transformers are used in alternating current installations for supplying the series (current) circuits of the indicating instruments, meters and protective relays. These transformers are designed to provide a standard secondary current output of 1 to 5 Amp. when rated current flows through the primary.

Instrument potential transformers are used in alternating current installations for supplying the potential circuits of the indicating instruments, meters and protective relays. These transformers are designed to provide a standard secondary voltage of 110 volts when rated primary voltage is applied to the primary.

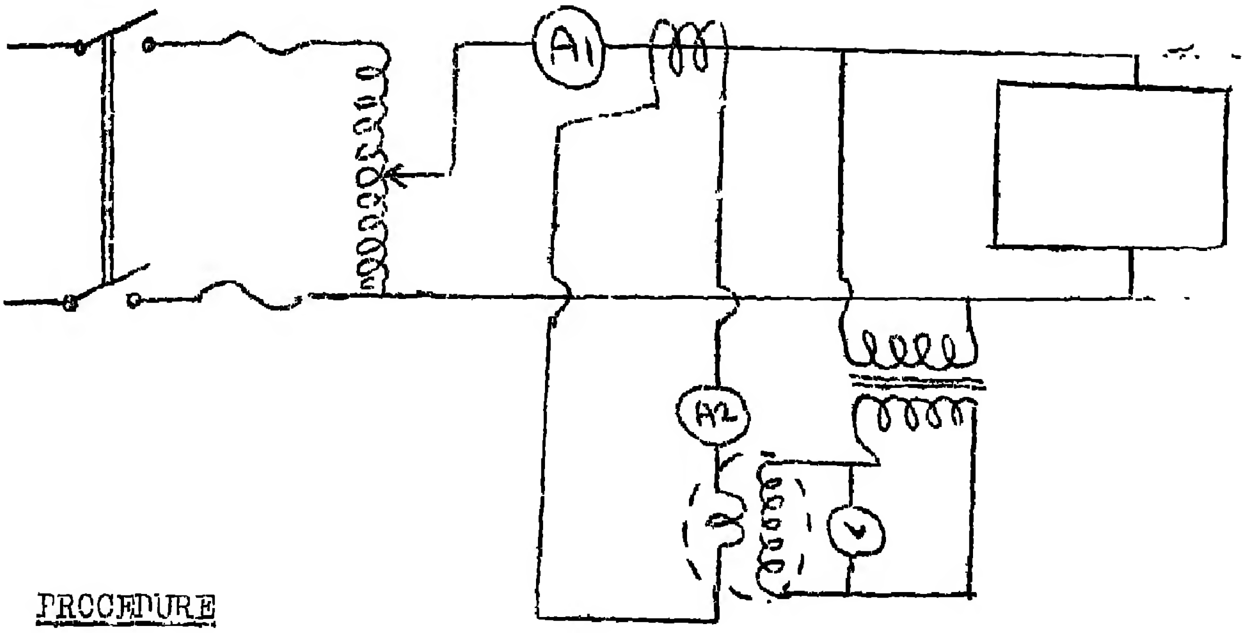
(ii) As instrument transformers are used mainly for measurement purpose, their ratio of transformation is accurate and phase angle error minimum. Other transformers are used mainly for changing the voltage level and as such are not as accurate as instrument transformer.

(iii) The primary of the current transformer is connec in series with the load where secondary winding connect are taken to the control room for purpose of metering protection. Instrument potential transformer primary is connected across H.V. side and secondary winding connections are taken to the control room for purpose of [illegible]

EQUIPMENTS AND MATERIALS

1. Instrument current transformer
2. Instrument potential transformer
3. A.C. Ammeters - 2
4. A.C. Voltmeters - 2
5. Energy meter
6. Connecting wires
7. Variable load (lamp load or resistive load)
8. Auto transformer.

CIRCUIT DIAGRAM



PROCEDURE

1. Make the connection of the circuit as shown in the circuit diagram.
2. Adjust the auto transformer setting such that reading of voltmeter V_1 corresponds to the rated voltage of the primary of P.T.
3. Adjust the load magnitude such that reading of ammeter A_1 corresponds to the rating of primary side C.T.
4. Record the readings of ammeter A_2 and Volt meter V_2.
5. Change the load magnitude to obtain different readings of ammeter A1 & the corresponding readings of A_2.
6. Change supply voltage to obtain different readings of volt-meter V_1 and the corresponding readings of V_2.
7. Calculate ratos of A_1 & A_2 & V_1 & V_2 for each observations

TABULAR RECORD OF OBSERVATION

S.No.	Readings of				A_1/A_2	Difference between marked ratio and	
	V_1	V_2	A_1	A_2		A_1/A_2	V_1/V_2

PRECAUTIONS

1. Before switching on the supply ensure that auto transformer setting is at the minimum.

2. Secondary of C.T. should never remain open.

QUESTIONS FOR EVALUATION

1. Why secondary of C.T. should never be open circuited when its primary is carrying current.

2. How would you identify the terminals of primary and secondary of a C.T.? of a P.T. ?

3. Where are the C.Ts and P.Ts connected in a circuit?

4. What are the uses of C.Ts and P.Ts ?

REFERENCES

1. Electrical measurements and measuring Instruments - E.W. Golding.

2. Electrical and Electronic Measurements and Instrumentation - A.K. Sawhney.

EXPERIMENT/PRACTICAL NO. 10

TITLE OF EXPERIMENT/PRACTICAL

Study of rectifier circuits.

SPECIFIC OBJECTIVES

1. To study half wave rectifier circuit.
2. To study full wave rectifier circuit.
3. To study the function of filter in full wave rectifier.

INTRODUCTORY INFORMATION & RELATED THEORY

Many appliances require D.C. supply for their operation e.g. electronic devices, electroplating, electric traction etc. Since the majority of supply systems are A.C it is necessary to change or rectify AC to DC. This is achieved by using rectifiers.

A rectifier offers a very low resistance to the passage of an electric current through it in one direction known as forward direction and a very high resistance to the passage of current in the opposite direction known as reverse direction. These devices enable A.C. to be changed to DC and this process is known as rectification.

(i) HALF WAVE RECTIFICATION

This is the simplest type of rectifier circuit. It allows only each alternate half-wave of AC to pass (Fig. 1(a))

(ii) FULL WAVE RECTIFICATION

This is obtained by using either two or four rectifier units. If two rectifier units are used, the supply is taken from a centre tapped transformer where the e.m.f. output of each half winding is equal to the e.m.f. required across the load. Each of the two circuits supplies the current in turn during

alternate half cycles (Fig.I(b)). An alternate method of full wave rectifier is to use a bridge circuit. This requires 4 rectifier units but does not require centre tapped transformer.

(iii) OUT PUT VOLTAGE

The forward voltage and the current flowing in a rectifier element consists of a series of pulses, the wave form of the forward pulse being similar to the inpu wave form over one half cycle. For a sinusoidal input the output voltage and current wave form will therefore be a series of sinusoidal half waves in the same direct Fig.1(d) & I(a).

The average value of the output voltage for a full wave rectifier operating from a sinusoidal input is calculated from:

Average value of output voltage = maximum value of outp voltage x 0.637

For half wave rectification, since every alternate pulse is missing, the average output voltage over a full cycle is calculated from average value of output voltage = $\frac{\text{maximum value of output voltage x 0.637}}{2}$

(iv) SMOOTHING

The pulsating wave form obtained directly from the rectifier is not suitable for practical application and requires smoothing. The smoothing circuit comprise a combination of resistance, capacitors & inductors. This combination is called a filter. These have been indicated at Fig.2(a)&(b).

EQUIPMENT AND MATERIALS

1. Metal rectifier 1 amp. 12v(max) 6 Nos.
2. Auto transformer - Input 230 V.AC
   - output (0-230)V.AC 5A. Single phase 50 HZ.

3. Step downtransformer; Single phase AC: 230/12V. IA 50HZ

4. i) Voltmeter - AC-0300 V - 1 No.

   ii) Voltmeter - AC-0-15/30.V - 1 No.

   iii) Voltmeter - DC ()-15) V - 1 No.

5. General purpose oscilloscope-double beam/single beam (as available)

6. Filter comprising 2 capacitors 8 MF each and one inductor of 5H inductance as required.

7. Connecting Jacks Plugs etc. as required.

8. Connecting wires (as required)

9. Soldering iron, solders B4 hand tools as required.

CIRCUIT DIAGRAM

The circuit diagrams are shown in fig. 3 & 4.

PROCEDURE

A. HALF WAVE RECTIFIER

1. Make connections as shown in Fig. 3

2. Keeping the auto transformer at the minimum position switch-on the main supply.

3. Adjust the voltage such that the voltage V_1 at the secondary is at the rated value of rectifier.

4. Connect the Oscilloscope probes to terminal (1) x (2) in the circuit.

5. Adjust the Oscilloscope sensitivity to obtain the best stable trace of transformer output.

6. Make a sketch of the voltage wave form as indicated at the oscilloscope.

7. Note the readings of Voltmeters V, V_1, V_2.

8. Remove the Oscilloscipe probes from terminals (1) & (2) and connect to terminals (3) & (4) and repeat steps 5 & 6 above.

9. Repeat the steps 3 to 7 with lower values of the rated voltage in steps upto 20% of the rated voltage.

10. Switch-off the supply.

B. FULL WAVE RECTIFIER (Without filter)

1. Make connections as shown in Fig. 4(a)
2. Repeat all the steps as shown for HALF WAVE RECTIFIER earlier.

C. FULL WAVE RECTIFIER (WITH FILTER)

1. Make connections as shown in Fig. 4(b)
2. Repeat all the steps as shown for HALF WAVE RECTIFIER earlier.

TABULAR RECORD OF OBSERVATION

A. HALF WAVE RECTIFIER

S. No.	VOLTMETER RDGS			OBSERVED VALUES AT OSCILLOSCOPE		CALCULATED VALUE OF OUTPUT D.C.	Remar
	V.	V_1	V2	AC Volts	D.C. Vlts		

B. FULL WAVE RECTIFIER(Without Filter)

S No	VOLTMETER RDGS			OBSERVED VALUES AT OSCILLOSCOPE		CALCULATED VALUE OF OUTPUT D.C.	Re
	V	V_1	V_2	AC Volt	DC Volt		

C. FULL WAVE RECTIFIER(WITH FILTER)

S No.	VOLTMETER RDGS			OBSERVED VALUES AT OSCILLOSCOPE		CALCULATED VALUE OF OUTPUT DC	Rem.
	V	V_1	V_2	AC Volt	D.C.Volt		

NOTE Compare the voltage values (DC) with and without using filter as also the values observed at OSCILLOSCOPE and calculated as per formula.

PRECAUTIONS

1. Make connections at the terminals neatly and tightly.

2. Do not exceed rated voltage and current at the instruments and apparatus.

3. Observe proper polarity while connecting instruments.

4. Rectifiers should be connected properly with correct polarity.

QUESTIONS FOR EVALUATION

1. Discuss the use of D.c. supply.

2. What is the effect of forward and revers bias on the performance of the rectifer.

3. Ex-plain the advantages of full-wave rectification over half-wave rectification.

4. Briefly explain the function of a 'filter' in the rectifier circuit.

REFERENCE

1. Electrical principles for installation and Craft students - Birchall and Stott.

2. Electronics for Electricians - Morris

3. Basic Electronics - GROB

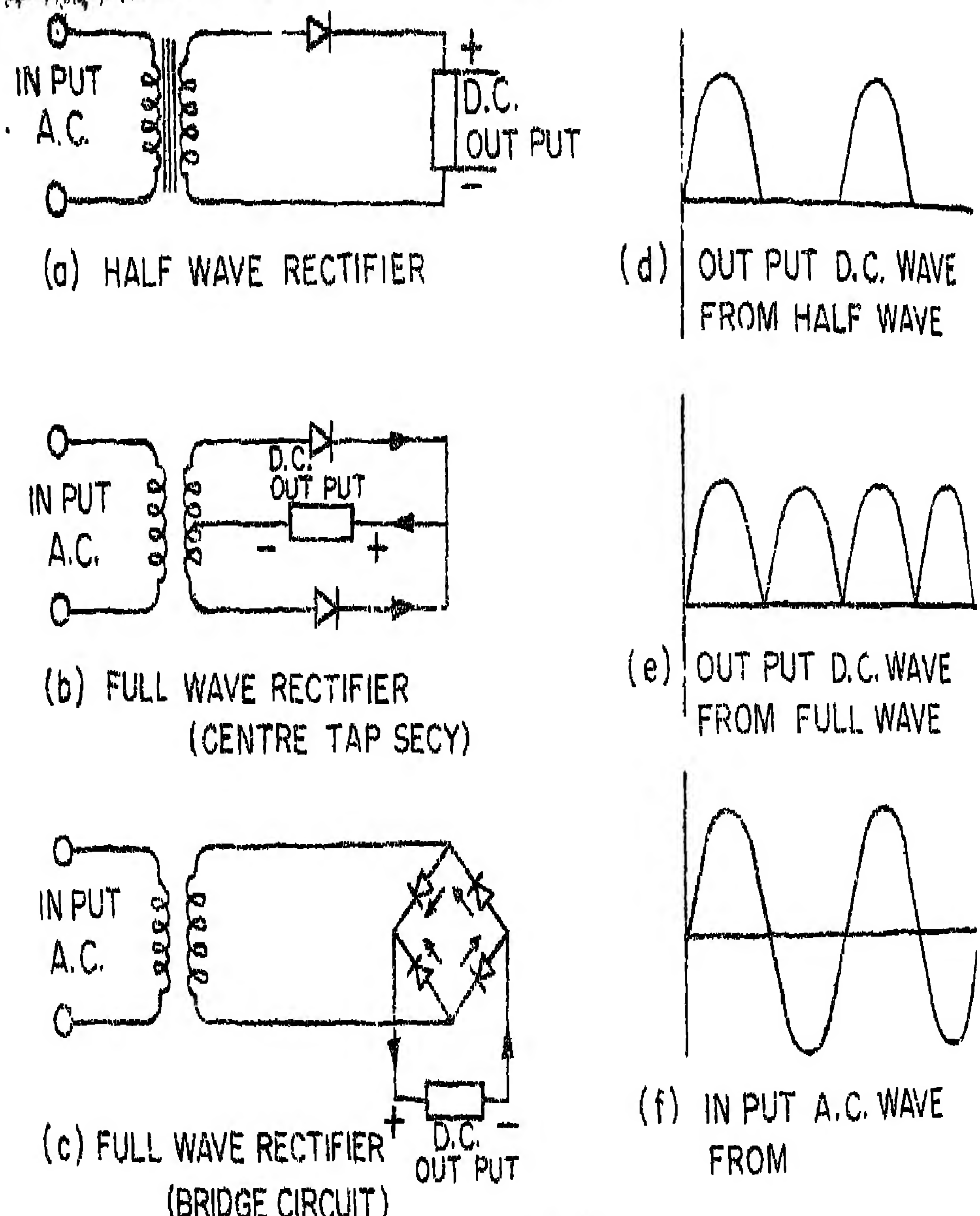

IN PUT
A.C.
D.C.
OUT PUT
(a) HALF WAVE RECTIFIER
(d) OUT PUT D.C. WAVE
FROM HALF WAVE
IN PUT
A.C.
D.C.
OUT PUT
(b) FULL WAVE RECTIFIER
(CENTRE TAP SECY)
(e) OUT PUT D.C. WAVE
FROM FULL WAVE
IN PUT
A.C.
(c) FULL WAVE RECTIFIER
(BRIDGE CIRCUIT)
D.C.
OUT PUT
(f) IN PUT A.C. WAVE
FROM

Fig 10·1

- 61 -

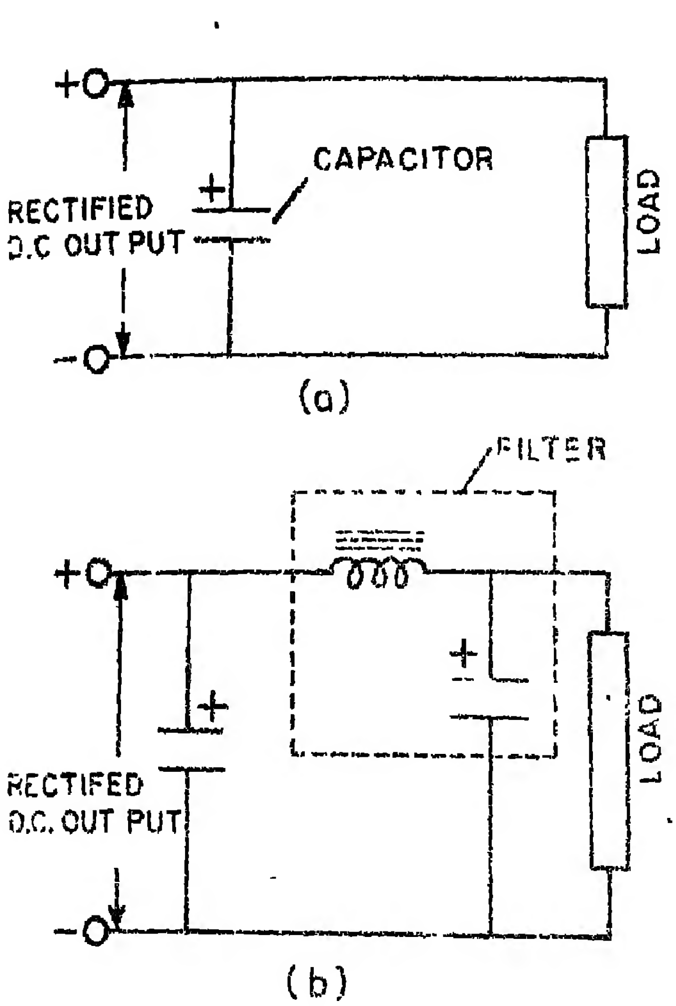


Fig 10·2a

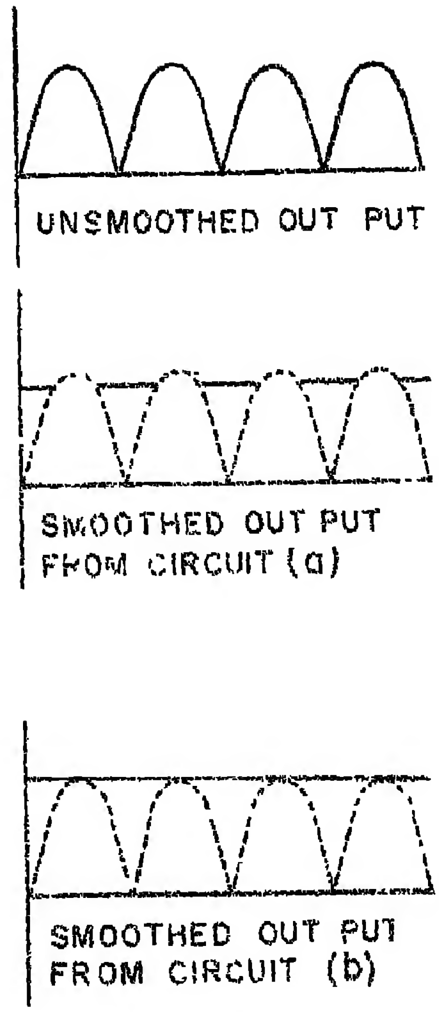


Fig 10·2b

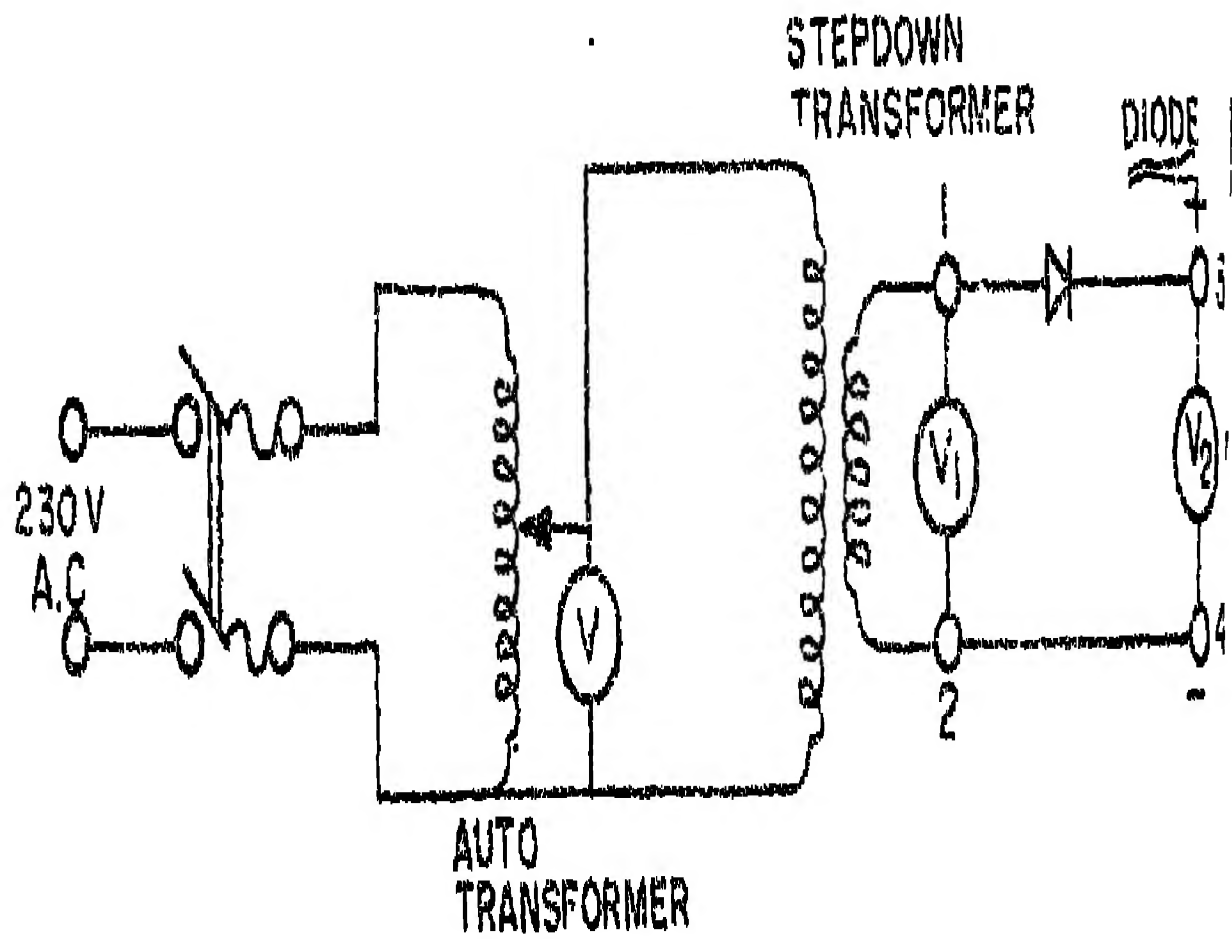

STEPDOWN
TRANSFORMER
DIODE
+
3
1
230 V
A.C
V
V1
V2
2
4
-
AUTO
TRANSFORMER

Fig 10·3

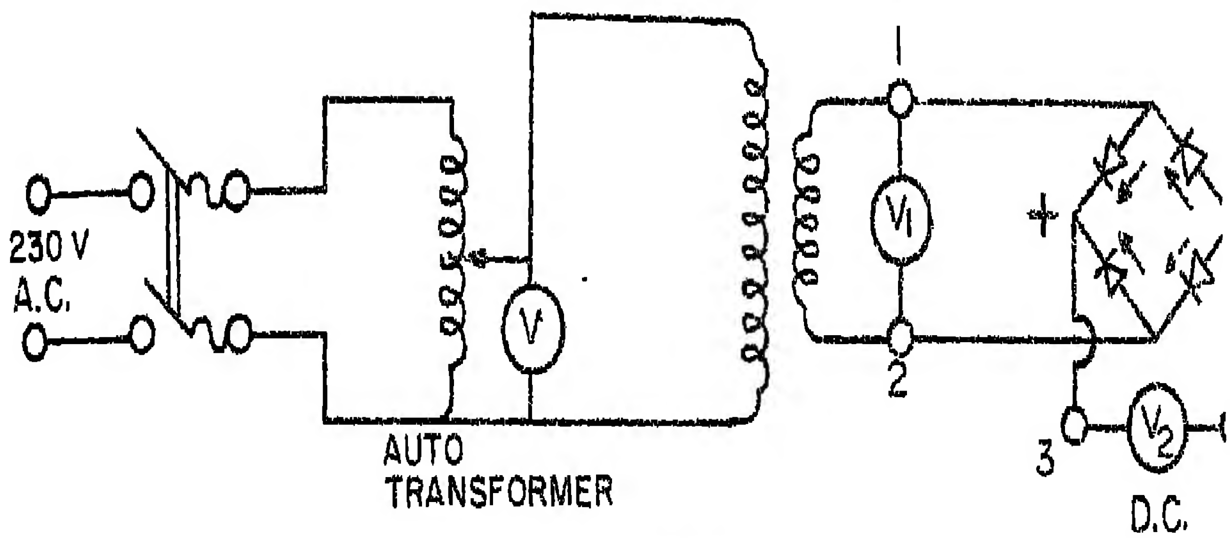


Fig 10·4a

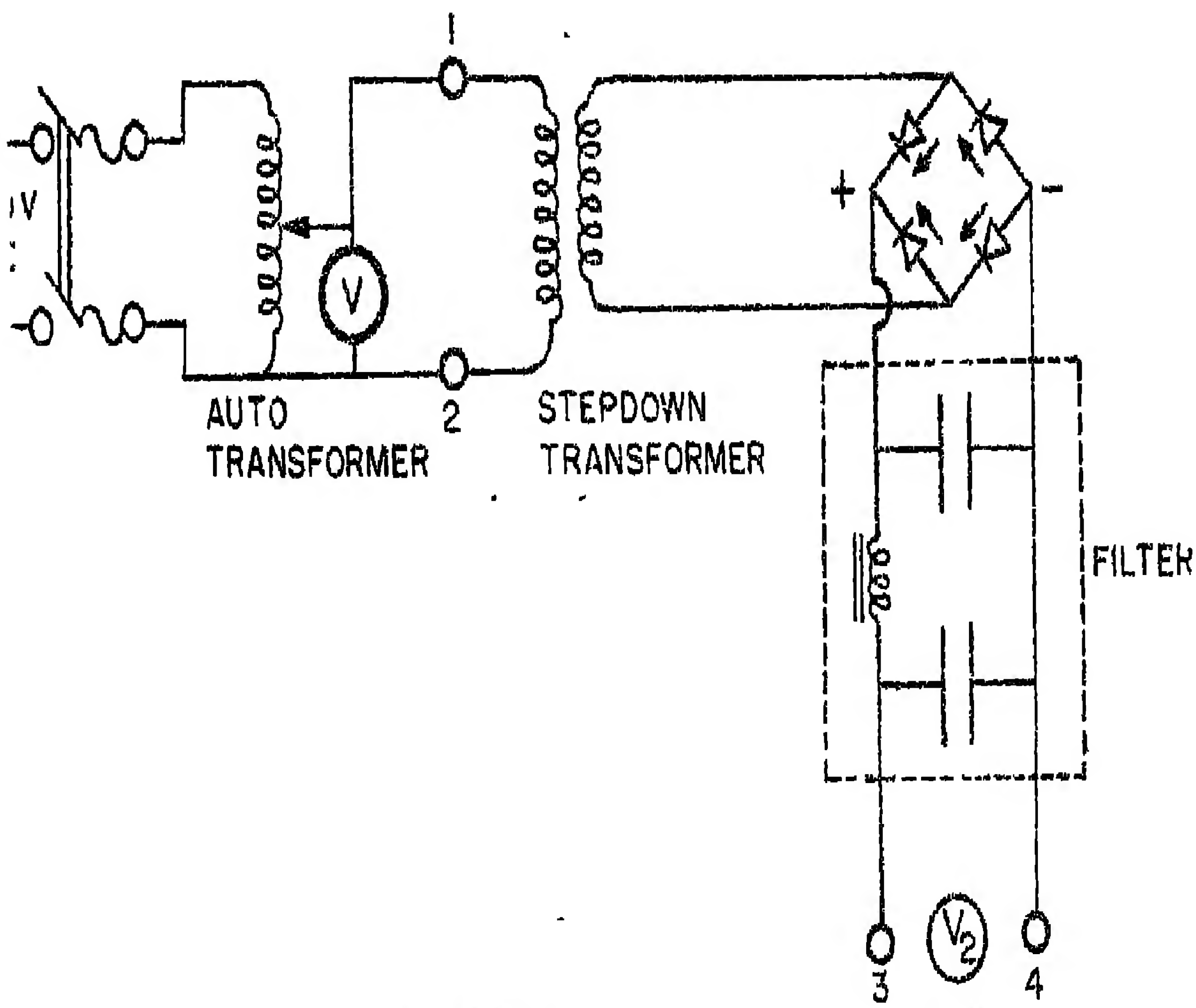


Fig 10·4b

EXPERIMENT No. 11

1. Title

TITLE OF EXPERIMENT/PRACTICAL:

Starting of a three phase induction motor with the help of a Direct on Line (D.o.L.) Starter.

SPECIFIC OBJECTIVES:

1. To study a D.o.L Starter.
2. To run the motor by using D.O.L. starter.

INTRODUCTORY INFORMATION AND RELATED THEORY:

A Direct on Line (D.O.L.) starter is a device which connects the electric motor to supply and provides protection against over current. D.O.L. starter is suitable for induction motors of 5 to 10 H.P. rating. Beyond 10 H.P., motor starters incorporate an arrangement of limiting the starting current also and therefore they donot put the motor directly on lines (D.O.L.)

Fig (1) shows the internal connection of the D.O.L. starter. It has the following parts:

(1) Three straight strips which join the motor directly to the supply. When "ON" push button is pressed, these strips make contact with the lower strips. See (1), (2) and (3) strip in Fig (1)

(2) Fourth strip works as interlock switch, i.e. when "ON" push button is released after pressing, current passes through this fourth strip.

(3) Overload protection mechanism consists of thick-wires, from which if more than normal current flows then they become hot and bimetallic strip placed inside bends and opens the overload switch, which further opens the no volt coil circuit and thus stops the motor.

EQUIPMENT AND MATERIALS:

1. Direct on line starter
2. 5 H.P. Induction motor
3. Techometer.

CIRCUIT DIAGRAM:

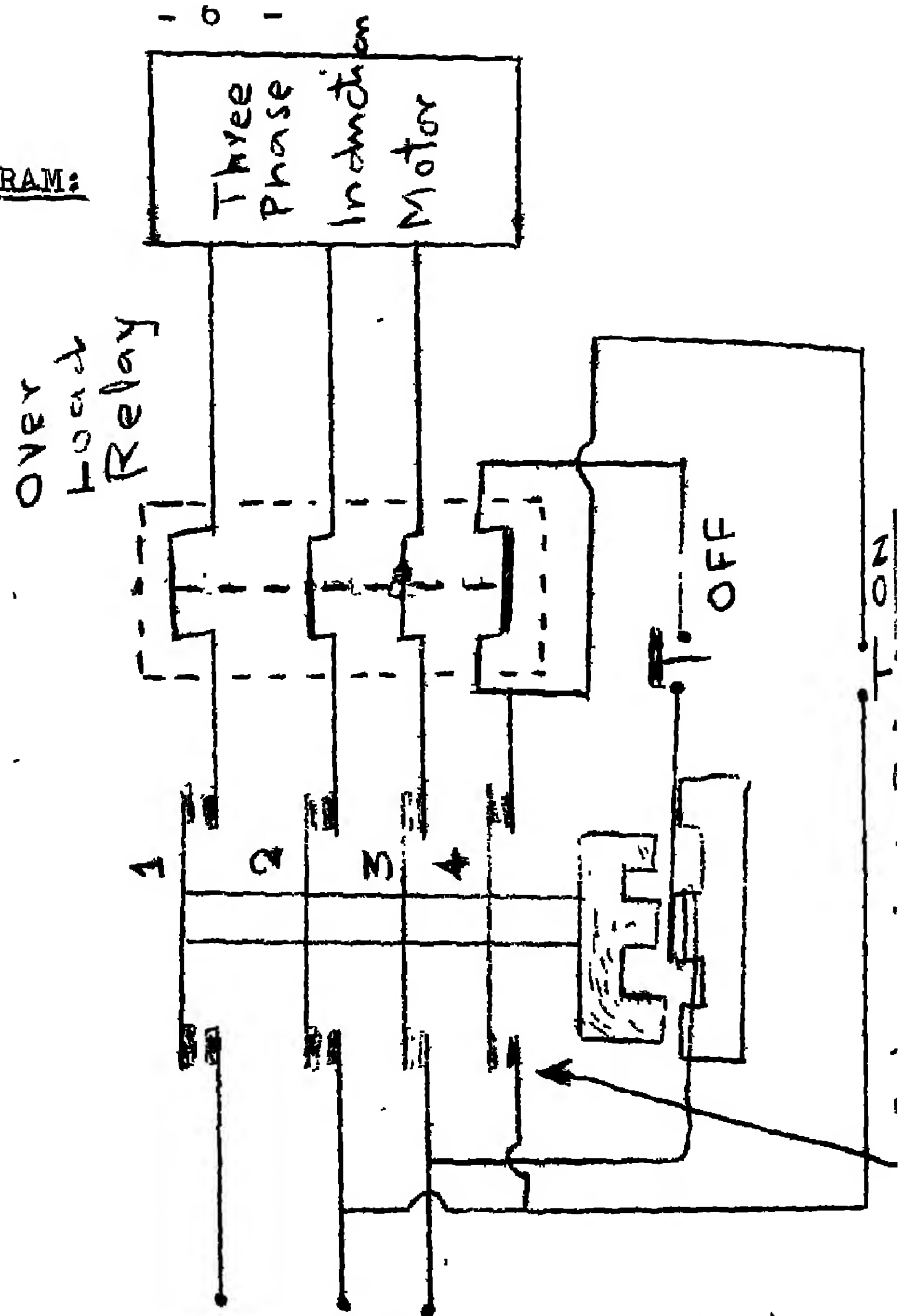


Fig. Three phase supply

PROCEDURE:

1. Open the cover of D.O.L. starter and trace the connections.
2. Draw the connection scheme of D.O.L. starter under s
3. Replace the cover and connect the starter to inducti motor.
4. Press the "ON" push button, allow the motor to run.
5. Measure the speed of the motor with the help of a technomotor.
6. Switch off the motor by pressing "OFF" push button

TABULAR RECORD OF OBSERVATION:

S. No.	Name of the Components	Specifications	No

PRECAUTIONS:

(i) Donot open the cover of the starter, before ensuring that main supply switch is off.

(ii) Donot switch on the supply till the cover of the starter has been replaced.

QUESTIONS FOR EVALUATION:

1. What is the need of a starter?
2. Write the various functions of the starter.
3. How overload protection function in D.o.L. starter.

REFERENCE:

1. Available manual of the starter
2. Electric motor winding and repair

by M.L.Anwani

EXPERIMENT/PRACTICAL NO: 12

TITLE OF EXPERIMENT/PRACTICAL:

Manual star-delta starting of a three phase squrrel cage induction motor.

SPECIFIC OBJECTIVES:

1. To understand principle of operation of star delta starter.
2. To understand the functioning of a manual star-delta starter.
3. To connect a star-delta starter and run the motor.
4 To be able to locate a fault in the circuitary or the components of the starter.

INTRODUCTORY INFORMATION AND RELATED THEORY:

A normal three phase induction motor draws 6 to 8 times its full load current on switching directly to the mains. The high starting current is associated with two very important disadvantages.

1. voltage fluctuations in the line
2. chances of damage to the motor and instruments.

The supply authorities have therefore put a restriction that all the induction motors with ratings more than 10 hp must be controlled to reduce the starting current. One of the most popular method for this purpose is star-delta starting. But this can be used only in case of a squirrel cage induction motor which is designed for normal delta running and has all the six terminals of the three winding.. brought out at its terminal flats as shown in Fig. 1

The starter has a no-volt release which releases the handle to fly back to the 'OFF' position under the following contingencies:

1. Supply failure
2. Over-loading
3. Pressing of stop button.

At the time of switching on the three windings are connected in star as shown in Fig. 2 and the voltage across each winding is only $\frac{1}{\sqrt{3}}$ times the supply voltag

See Fig. No.1, Fig. No.2 and Fig. No. 3 in the attached sheet.

On picking up the speed by the motor, its connecti are charged to delta by a switch(star-delta switch) to it available full voltage.

EQUIPMENT AND MATERIALS:

1. One 3-phase squirrel cage induction motor.
2. One manual star-delta starter.
3. One multimeter.
4. One ampere meter of rating at least double the full load line current of the motor.
5. Necessary tools, connecting leads etc.
6. One voltmeter 0-500 V.
7. One technometer.

CIRCUIT DIAGRAM:

See Fig No. 4 in the attached sheet.

PROCEDURE:

1. Open the lid of the starter and study its circ
2. Identify the six terminals of the three windin XY, WZ.
3. Make the connection of the starter, instrument etc. as showin in Fig. No.4
4. Start the motor by throwing the switch to star position and allow the motor pick up speed. Record the instrument readings.
5. Change over the starter to delta position and take the same readings again.

TABULAR RECORD OF OBSERVATIONS:

- AT NO LOAD

S.No.	Position	Supply Voltage	Voltage across winding	Line current	Current the winding	Speed
1.	Y					
2.	Δ					

PRECAUTIONS:

1. Before starting make ensure that the terminals of the starter have been connected properly to the motor.

QUESTIONS FOR EVALUATION:

1. What is the function of the no-volt release?
2. What is the advantage of star delta starter over direct starting?
3. There is a 15 h.p. 400 V 50 H 3 phase squarrel cage induction motor. How much starting current approximately will it draw when started with the help of a star- delta starter.
4. Is it possible to use star-delta starter for a motor having normal operation in star?
5. Why is a star-delta starter not normally used to start a Ilip ring motor?

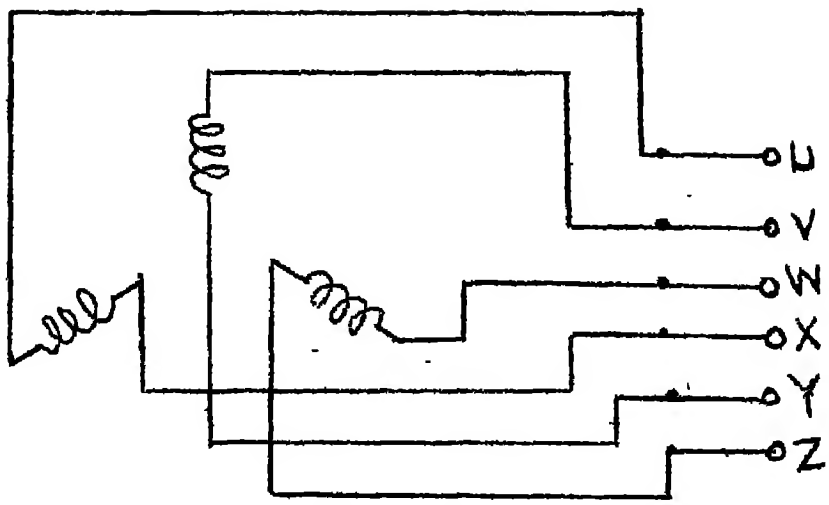


Fig: 1

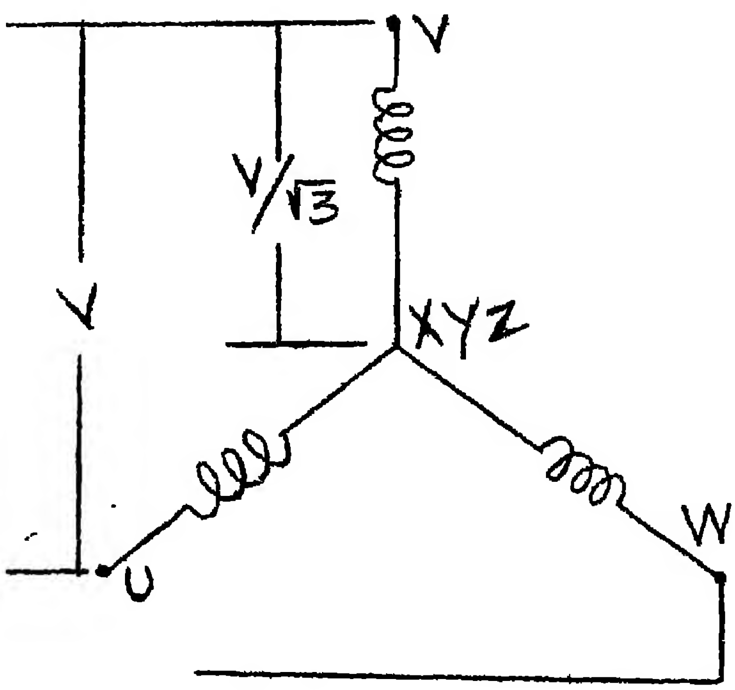


Fig: 2

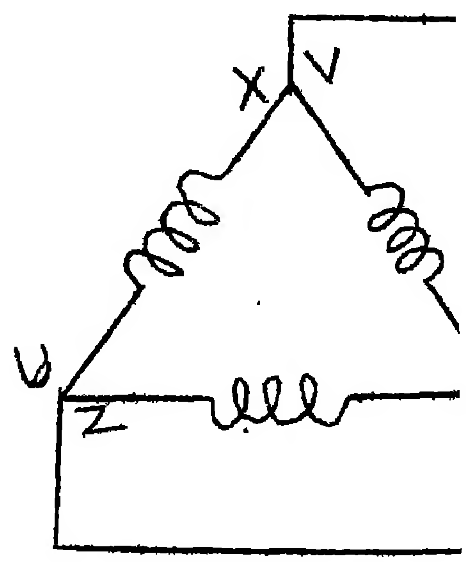


Fig: 3

SKay
25.9.84.

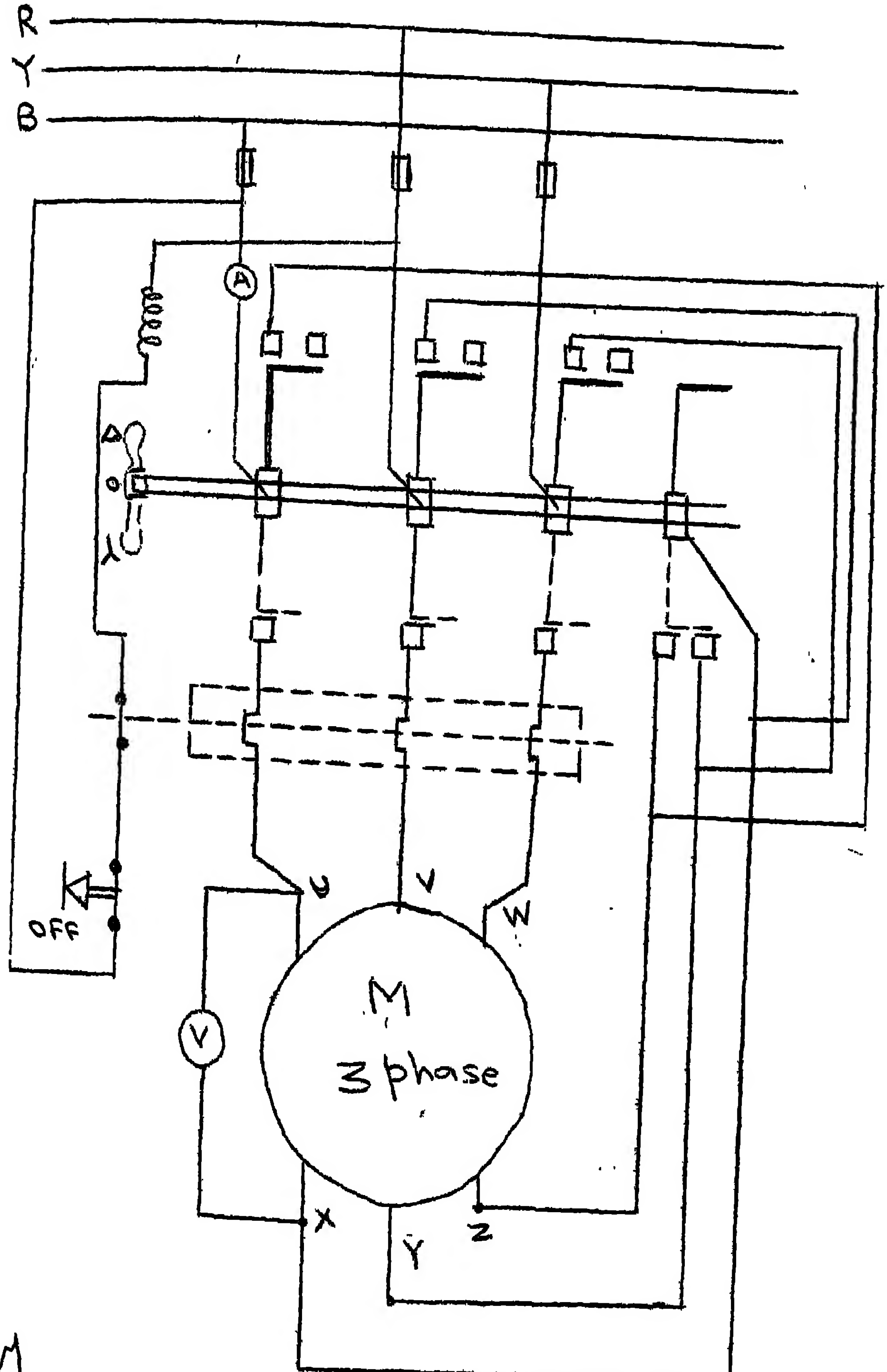


Fig: 4

25.9.84.

EXPERIMENT / PRACTICAL NO: 13

TITLE OF EXPERIMENT:

Study of different types of protective switch gear.

SPECIFIC OBJECTIVES:

(a) To learn the functions and parts of a switch gear.

(b) To understand the function and the various types of circuit breakers.

(c) To name and understand the function and the various types of Relays.

INTRODUCTORY INFORMATION AND RELATED THEORY:

The switch gear is needed in a power system:

1. To permit electric system to be conveniently put into and taken out of service.
2. To enable the electric system to be isolated rapidly and safely in case of fault.

For low voltage applications, the above two functions can be performed by simple switches, isolators and fuses. Switch is generally a hand operated, knife blade type device which can make or break a circuit on load, where as Isolators are hand operated devices which can make or break the circuit on no load. Fuse is essentially a small piece of metal or wire inserted in a circuit to interrupt the circuit when current more than a predetermined value flows through it.

Ordinary switches and fuses are suitable only for low power circuits, because they are neither fast operating nor capable of extinguishing the arc while making and breaking the circuit. To over come these difficulties a switching equipment known as circuit breakers is used to make or break circuit automatically.

Circuit Breakers

Circuit breaker is a mechanical switch which is capable of making, carrying and breaking currents under normal circuit conditions and also under specified abnormal conditions such as those of short circuits. They break the circuit automatically and rapidly by spring or gravity action. They can make the circuit manually or by automatic means. As soon as circuit breaker is tripped, the load current is interrupted and an arc is drawn between the two contacts. In order to extinguish the arc as quickly as possible, the arc is surrounded by oil, air or gas. Accordingly the circuit breakers may be classified as follows:-

(a) Bulk oil circuit breakers-in which the oil serves as a gas generating medium and also as the insulator.

(b) Low oil content circuit breakers -- in which oil only serves as the gas generating medium, while solid dielectric parts isolate the two contacts.

(c) Gas blast circuit breakers -- in which the arc extension media is a stream of gas,, viz., sulpher hexa fluoride (SF_6)

(d) Air blast circuit breakers (ABCB) -- in which a stream of compressed air is employed for arc extinction.

Protective Relays:

Relays are the devices that detect abnormal conditions in electrical circuits by constantly measuring the electrical quantities (voltage, current, frequency etc.) which are different under normal and fault conditions.

According to construction and principle of operation the relays can be classified as:

1. Electromagnetic relays: - These relays are operated by D.C. or A.C. quantities. Moving iron, attracted armature, balanced beam etc. fall under this category
2. Thermal relays:- These relays are operated by thermal effect.
3. Physico electric relays :- Buchholz's relay is an example of physico-electric relay.
4. Static relays:- These relays employ transistors etc. for their operation.
5. Induction relays:- These relays use the principle of induction motor/energymeter.
6. Electrodynamic relays:- These relays use the principle of D.C. machine.

Protective relay detects the fault and operates to complete the trip circuit which in turn opens of the circuit which in turn opens of the circuit breakers. The operation has been illustrated in Fig. 1 which shows one phase operation only for simplicity.

The aims of properly designed switch gear are:

(a) Reliability: - The switch gear should be completely reliable to improve the reliability of the electric system as a whole.

(b) Discrimination:- The switch gear should be able to discriminate perfectly between healthy and faulty sections of the electric system. In the event of fault, the switch gear should isolate only the faulty section.

(c) Quick Operations:- The switch gear should operate quickly so that no damage is caused to electrical machines and equipments by short circuit currents.

The switch gear should be very sensitive, simple, robust and easy to maintain. Various types of switch gear are:

(i) metal clad switch gear

(ii) metal enclosed switch gear.

(iii) truck or draw out type.

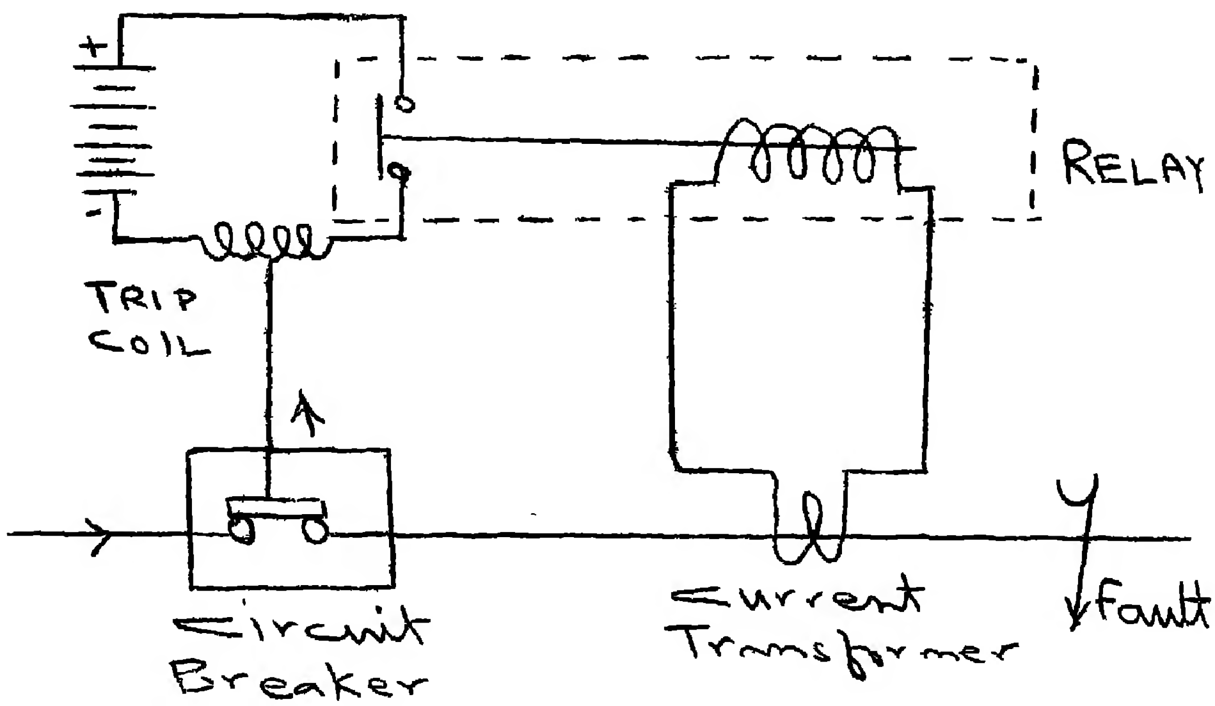


Fig. 1

EQUIPMENT AND MATERIALS:

Circuit breaker, Relay, Semi enclosed rewireable fuse wire gauge.

PROCEDURE:

Circuit Breaker:

(a) (i) Name the type of circuit breaker.

(ii) Name the various parts of the circuit breaker

(b) RELAY

(i) Name the type of relay.

(ii) Name the principle of operations of relay.

FUSE

(i) Name the material of the fuse.

(ii) Find out the gauge no. of the fuse with the help of standard wire gauge.

(iii) State the relation between gauge no. and current carrying capacity of fuse.

(iv) Name the various types of commonly used fuses.

PRECAUTIONS:

Nil

QUESTIONS FOR EVALUATION:

1. Name the most commonly used type of switch gear in H.T. System.
2. State the advantages of circuit breaker over manual switch
3. Name the type of oil used in oil circuit breaker.
4. What is the range of pressure of compressed air in Air Circuit Breaker?
5. Upto which level of voltage, a switch is suitable for making and breaking the circuit.
6. State the functions of a relay.

REFERENCES:

1. Generations, transmission and utilization of electrical power by A.T. Starr.
2. A course in electric power by M. Soni, Gupta and Bhatnagar.

EXPERIMENT/PRACTICAL No: 14

1. TITLE OF EXPERIMENT/PRACTICAL:

Study of the construction ~~and working of lead-acid~~ batteries.

.. SPECIFIC OBJECTIVES:

1. To identify the different parts of the lead acid battery.
2. To study the working of the battery.
3. To prepare an electrolyte for the battery.

INTRODUCTORY INFORMATION AND RELATED THEORY

I. Introduction: Lead acid battery is also known as storage battery. A storage battery is a chemical device reversible in its action, which stores energy at one time for use at another. The energy stored is chemical, not electrical. Electrical energy in the form of direct current electricity is applied to the battery during the operation termed 'charging' (explained in the next experiment). The electric current produces chemical changes in the battery and the chemical energy stored in the plates is reconverted to electrical energy when the cell is discharging.

There are two general types of storage batteries:-

1. The lead-acid type.
2. The nickel-iron type.

For the purpose of this experiment, only the lead acid type will be considered.

II. Construction of Lead Acid Battery: The following are the important component parts of the lead acid battery:-

1. Positive plates.
2. Negative plates.
3. Active liquid
4. Separators
5. Container

6. Top cover.

A brief description about each of the above is given below:-

1. Positive Plate

There are two general types of plates of plante type, one type of Plante plate is a casting of pure lead consisting of numerous thin vertical laminations strengthened by a [illegible] of horizontal corss ribs. (Fig.1 (a)) The effect of the lamination is to increase the superficial area of the plate by as much as 12 times as that of a plain lead plate of similar width and length. Almost the whole of this develope area is available for conversion to active material (lead peroxide PbO_2) by electrochemical action.

A second type of Plante plate which is still wide used is the rosette plate. This is an antimonial-lead casting perforated with numerous holes in which are plugged rolls of previously crimpled lead tape or "rosettes". During this formation, the surface of the lead tape of rosettes is converted to active materia (see Fig. 1 (b)).

2. Negative Plate: Two types of negative plates are available - a box negative with a heavy plante plate and a pasted negative (Pb) with the lighter high performance Plante plate.

The box negative consists of a pair of antimonial lead alloy grinds, each with an outer surface covered with a thin sheet of perforated lead. After applying the plaste, the two girds are riveted together (Fig. 3 (c)).

3. Active Liquid: The active liquid is dilute sulphuric acid (H_2SO_4) of specific gravity of about 1.2. In fully charged condition, the sp. gravity rises to 1.28 and its e.m.f about 2.2 volts.

In fully discharged condition the sp. gravity falls to 1.13 and the e.m.f falling to about 1.8 Volts.

The table 1 indicates the condition of different stages of charge.

TABLE 1 SHOWING THE SPECIFIC GRAVITY OF ELECTROLYTE AT DIFFERENT LEVELS OF CHARGE

SPECIFIC GRAVITIES		CHARGE
From	To	
1.260	1.230	100% charge.
1.230	1.250	70% charge.
1.200	1.220	50% charge.
1.170	1.190	25% charge.
1.140	1.160	Very little useful capacity
1.110	1.130	Discharged.

4. Separators: Separators are used to insulate the adjacent plates (positive and negative) from one another.

The separators may consist of wood veneers, microporous plastic veneers or glass tubes.

Glass tubes of different length and diameter to suit the various cell sizes are pushed down between the plates so as to rest on the bottom of the cell box. They are held in a vertical position by location in guides in the top of the plates.

Wood separators are made of thin sheets threaded through two or more slitted wooden rods or dowels which support the veneers in the correct position between the plates. Wood separators are now largely being replaced by sheets of microporous plastic threaded through slitted rods of polystyrene.

5. Container: Plate groups are assembled in transparent plastic boxes sealed with lid (for portable batteries or in glass containers or open lined wooden boxes

(for stationery batteries only) Plastic ... containers for cells upto about 2000 Ampere/Hour capacity. Cells of larger capacity are assembled in lead lined wooden containers.

When plastic box is used, the plate groups are supported by the plate lugs resting on shoulders moulded in a box. In lead lined wooden boxes, the lining is carried over the top edges of the box. The plates are supported on glass slabs projecting above the top edges. These glass slabs are ... in lead grooves in the base of the container.

Cells may be interconnected either by bolting the terminal bars together or moulding the plate lugs of adjacent cells to a common terminal bar.

6. Top Covers — ... or other of corrosion resistant type as container is placed over the element and fixed air tight to the top of the container to exclude dirt or foreign material and reduce evaporation of water from the electrolyte. The cover has a vent plug which has small holes for evaporation of gas which can be removed for adding water and taking hydrometer reading.

III. ... Charging & Discharging:

As already mentioned, the acid liquid is dilute sulphuric acid (H_2SO_4). The positive plate is lead peroxide (PbO_2) and the negative plate spongy lead (Pb).

During discharge, the active material at both the plates is partially converted to lead sulphate ($Pb\,SO_4$) and the ... becomes more dilute or lower in its specific gravity.

During charge, a reverse action takes place. The sulphate from both the plates is converted into lead peroxide on the positive and spongy lead on the negative plate. ... specific gravity ... to it's original value.

The reactions may be stated in short.

$$\underset{(+ve)}{PbO_2} + \underset{(-ve)}{Pb} + 2H_2SO_4 \underset{\longleftarrow}{\xrightarrow{DISCHARGE}} \underset{(\text{both} + ve\ -ve)}{2PbSO_4} + 2H_2O$$

EQUIPMENT AND MATERIALS:

1. Used batteries (lead-acid type) 3 Nos. without active liquid. (at least one in working condition).
2. Glass Jars — 5 litres capacity; 1 litre capacity
3. Hydrometer ... 1 No.
4. Sulphuric acid (density 1.835) ... 1 litre
5. Distilled water ... 5 litres
6. Glass rods ... 2 No.
7. Hand gloves ... 4 Nos or 2 sets.
8. Spanners, Hand tools etc .. (as required).
9. Glass or wooden tray .. 80 cm x 40 cm - 2 Nos.

CONNECTION DIAGRAM:

(The students should make out sketches of all the important part of the given battery).

PROCEDURE:

A. Identification of Parts of Lead Acid Battery:

1. Strip open the battery and take out the parts. (only the battery with no active liquid should be selected)
2. Study and note the constructional features of the following:
   - i) Positive plates.
   - ii) Negative plate.
   - iii) Separators.
   - iv) Terminals.
   - v) Fixing arrangements of separators and plates.
   - vi) Container.

B. <u>Preparation of Electrolyte for Lead-Acid.</u>

<u>Battery</u>: (To be used in new battery or for repair work).

1. Take 3 litres of distilled water in a glass jar and one litre sulphuric acid in another.
2. Add acid slowly in water and stir continuously with a glass rod.
3. Take specific gravity readings (with hydrometer) and make final adjustment of the sp. gravity to the desired value after the electrolyte has cooled to room temperature.

<u>TABULAR RECORD OF OBSERVATIONS:</u>

After studying the constructional details of battery, answer the following:

1. What is the material used for positive plate...
2. - do - - do - negative plate...
3. - do - - do - separator ...
4. How many negative plates are available.......
5. How many positive plates are available.......
6. What is the material for the container......
7. (i) What is the area of each plate....
   (ii) - do - - do - all the positive plates
   (iii) - do - - do - negative plates.
8. What are the name plate details of the battery....
9. What is the material used for terminal post....

<u>PRECAUTIONS:</u>

1) Always handle the battery and its parts with hand gloves in position as the acid is corrosive.
2) Always pour the acid into the water and not water into the acid.
3) Heat is produced when the acid is mixed with water. Allow to cool before the hydrometer reading is taken.

4) To mix or store electrolyte use only glass or lead lined containers as this is highly corrosive.

QUESTIONS FOR EVALUATION:

1. Explain the difference in the construction of positive and negative plates of lead-acid battery.
2. What is the composition of the electrodes (plates) and electrolyte of a fully charged lead-acid cell?
3. At what output voltage is a lead acid cell completely discharged?
4. How is the specific gravity of the electrolyte related to the charge of a lead acid cell?
5. What is the specific gravity of:

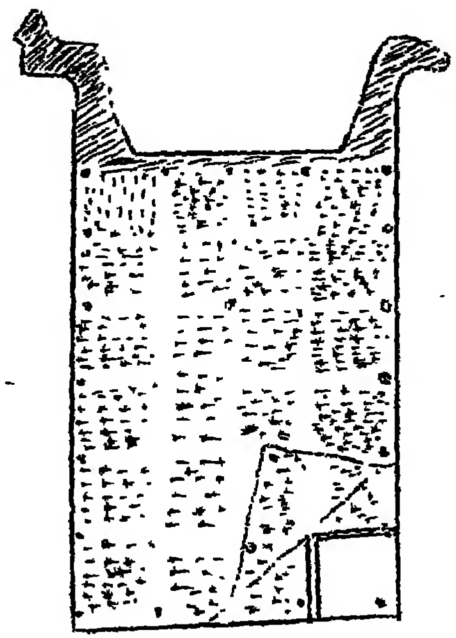
   (a) a fully charged lead-acid cell.

   (b) a fully discharged cell.

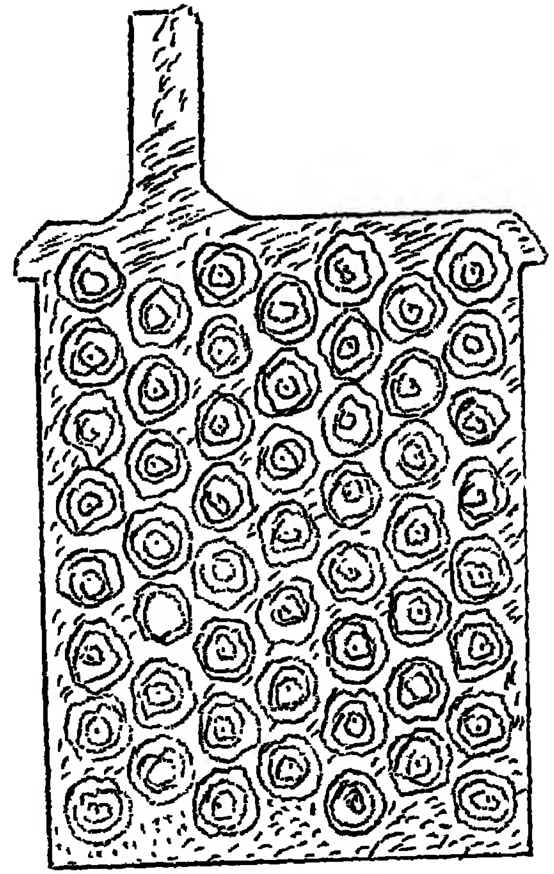
REFERENCES:

1. Storage Batteries - G. Smith.
2. Electricity Vol.6 - Harry Mile Af.

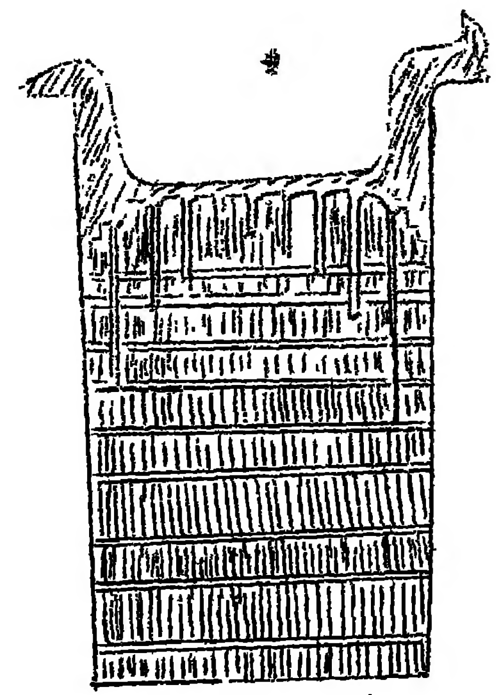
27.9.89.



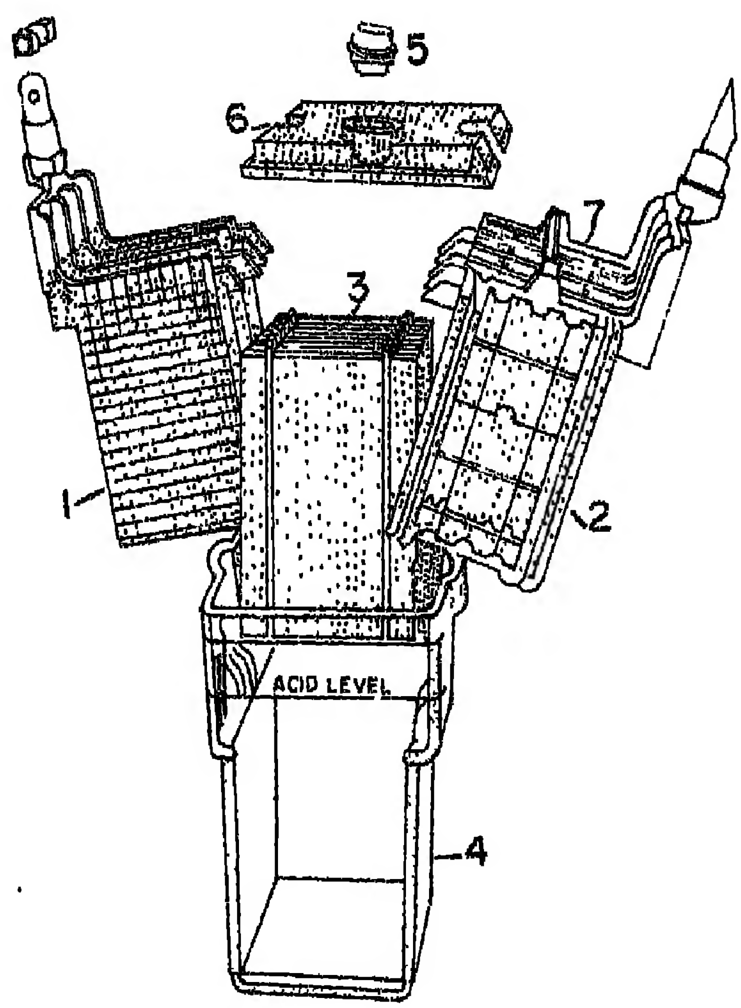
Box Negative Plate
Fig. I (c).



Rosette Positive Plate
Fig. 1 (b)



Plante Positive Plate
Fig. 1 (a)



1. POSITIVE PLATE GROUP
2. NEGATIVE PLATE GROUP
3. SEPARTOR DIAPHRAGMS AND DOWELS
4. GLASS BOX
5. VENT PLUG
6. HARD RUBBER LID
7. SEPARATOR HOLD DOWN ROD

Fig 14·1d

EXPERIMENT / PRACTICAL No: 15

TITLE OF EXPERIMENT / PRACTICAL:

Charging of Batteries.

SPECIFIC OBJECTIVES:

1. To differentiate between the different methods of charging.
2. To prepare a battery for charging.
3. To connect a Battery on constant-potential Method charge.
4. To connect a Battery on constant-current method charge.
5. To test Battery after charging.

INTRODUCTORY INFORMATION AND RELATED THEORY:

Lead acid Batteries store the electrical energy by chemical action. They get discharged due to the constant use. The voltage per cell falls below 2 Volts and the specific gravity of electrolyte decreases to 1.125 when fully discharged. Charging of storage batteries is hence very much essential to keep them fit for use. On charging the voltage per cell will increase to 2.2 V on open circuit and 2 V on load. Specific gravity of electrolyte increases to 1.280.

Only direct current is suitable for charging the batteries. D.C. supply may be obtained from any source such as M.G. Set or a Rectifier. Care should be taken to see that the positive of the supply is connected to positive terminal of the battery and negative of the supply to the negative terminal of the Battery while connecting it for charging.

(a) Charging time, current and voltage:

Where time is an important factor in recharging as in many industries using battery operated electric trucks or vehicles etc., then high charge current is required to replace the energy taken out of the battery. Charging at high rate for short period is called boost charge. Boost charge should generally be avoided as this reduced

the life of the battery. 20-30 percent of the battery capacity can be restored in an hour with boost charge.

(b) Charging Current:

This must normally comply with recommendation of the battery manufacturer. Generally not more than 1/10 of ampere hour capacity for 10 hr. charge or Slow charge for 20 hrs. at 1/20 of ampere hour capacity is recommended depending on the time available for charging.

(c) Charging Voltage:

Generally for normal charging 2.5 to 2.65 volts per cell is used. For trickle charge this voltage should be between 2.2 and 2.3 per cell.

(d) Charging Methods:

There are two methods by which a battery can be charged:

i. Constant Current Charging:

Any available D.C. Voltage can be used for this method. Battery is connected to the D.C. mains through loading resistance. When number of batteries are to be charg[illegible] they are connected in series with a Resistance to mains. Same capacity batteries should be grouped together. When different capacity batteries are to be charged current should not exceed the value required for the smallest capacity battery. In order to maintain constant current throughout the charging period, the resistance of the circuit is adjusted frequently during the period. Arrangement for constant current charging is shown in figs. 1 & 2

Charging Current can be calculated as follows:-

$$I\ charge = \frac{V - Vb}{R + r}$$

V - Supply Voltage

Vb - Voltage across the battery terminal

R - Loading resistance in ohms

r - Internal resistance of the ba[illegible]

r - ~~Internal Resistance of the battery.~~

ii. Constant Voltage Charging:

A battery Charger or a D.C. source of definite voltage is required for this method. Batteries of the same voltage are connected in parallel across the source. Capacity need not be the same. Charging current gets adjusted by itself according to the condition of charge left. Charging voltage generally set to 2.5 to 2.65 v per cell. Charging ~~current tapers off to very~~ low value as the battery gains charge. Once the battery is put on charge no further adjustment of voltage or current is necessary. Arrangement for constant voltage charging is shown in fig. 3 .

Most modern charging equipment make use of a.c. supply with rectifier to obtain requistic d.c.

This results in safe and flexible control of battery charging either automatically or with the minimum manual attention.

iii. Trickle Charge:

Trickle charge is usually applied to any low-rate charge in amperes equal to 0.05 to 0.1 percent of the battery capacity i.e. 0.5 to 0.1 per Ah capacity. This trickle charge current is sufficient to balance the internal losses of the battery, and therefore keeps the battery in a fully charged condition. It is used for maintaining batteries in charged condition during fairly lenthy storage periods.

iv. Float Charging:

Batteries which are used as source of standby power in case of emergency are permanently connected across the system or lead. The battery is floated across the system in parallel with a rectifier charger which

is voltage ~~controlled to comply with~~ the permissible limits of the system.
Under true float conditions the battery neither discharges nor charges. In order to keep it healthy and fully charged, a trickle charge is allowed. Under these conditions the battery is operating on float/trickle charge, and the number of cells in the battery is selected so that the applied system voltage is equivalent to about 2.15 - 2.20 V per cell.

Floating battery systems are widely used for power stations, emergency lighting and telephone exchange installations.

EQUIPMENT AND MATERIALS:

1. D.C. source of any available voltage.
2. Battery charger for 6V/12V battery.
3. Connecting leads with battery clips.
4. Distilled water.
5. Petroleum jelly.
6. Hydrometer.
7. Cell tester.
8. High rate discharge tester.
9. Variable resistance or lamps with holder and switch.
10. Battery to be charged.

CIRCUIT DIAGRAM:

(A) Constant Current Charging

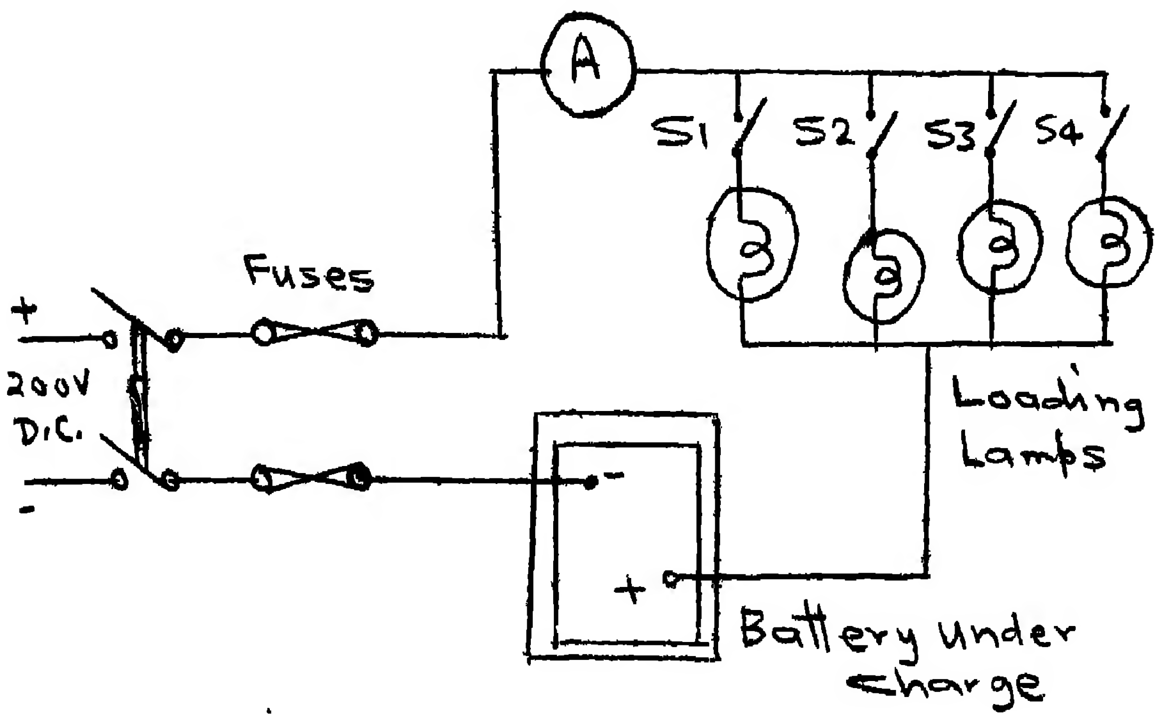


Fig. 1 Connection of one Battery

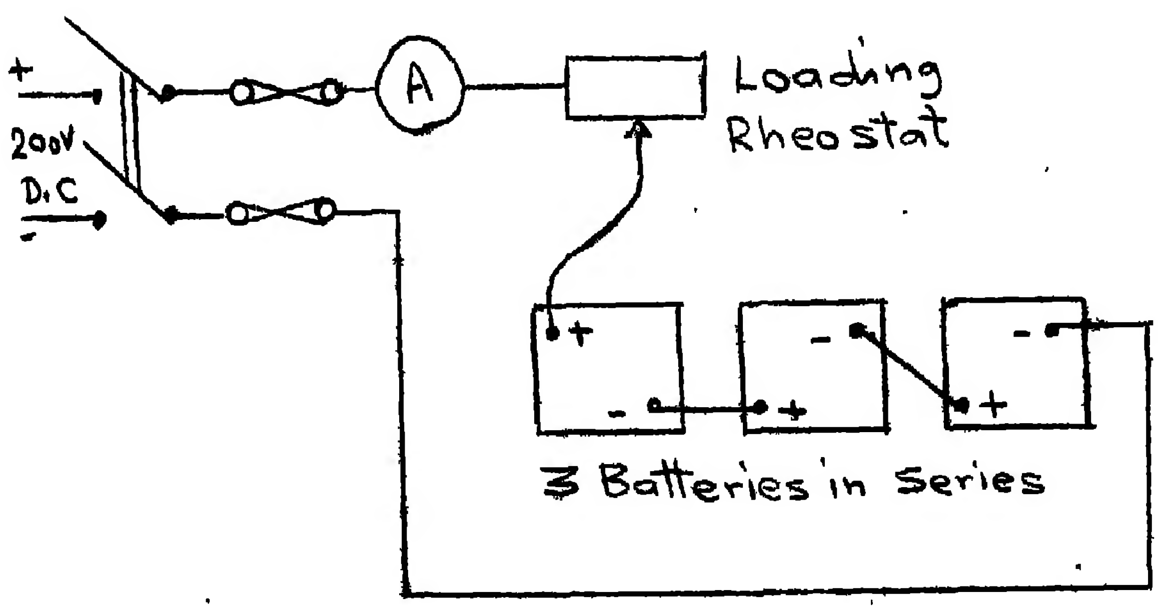


Fig. 2 Connection of 3 batteries in Series

PROCEDURE:

1. Clean the battery and its terminal posts.
2. Remove the vent plug and check the electrolyte level.
3. Top up with distilled water (The level should be as marked on the battery or 1 to 1.5 cm above the top of the plate).
4. Measure the voltage of each cell or the whole battery and check the specific gravity of electrolyte in each cell.
5. Connect the battery to the supply through lamps or resistance and ammeter as shown in the figure 1, (keep all the switches off).

   Note: Check for correct polarity of connection +ve of battery to +ve of supply and -ve to -ve. Avoid loose connections.
6. Adjust the resistance to highest value or keep all lamp switches in off position. Switch on the main switch.
7. Adjust the charging current as per requirement (e.g. $\frac{\text{A. hr capacity}}{10 \text{ or } 20}$) by adjusting the resistance or switching on the required No. of lamps.
8. Keep a watch on the charging current and adjust it to constant value throughout the charging period.

   Note: If too much gassing appears and Electrolyte starts boiling reduce the charging current.
9. Leave the battery in the circuit until it is fully charged:

Indication of fully charged battery	i. Violent gasing occurs. ii. Voltage per cell on open circuit increases to 2.2v per cell. iii. Sp. gravity of electrolyte increases to 1.280.

10. Disconnect the battery from the charging circuit, check voltage, specific gravity, and test by high rate discharge

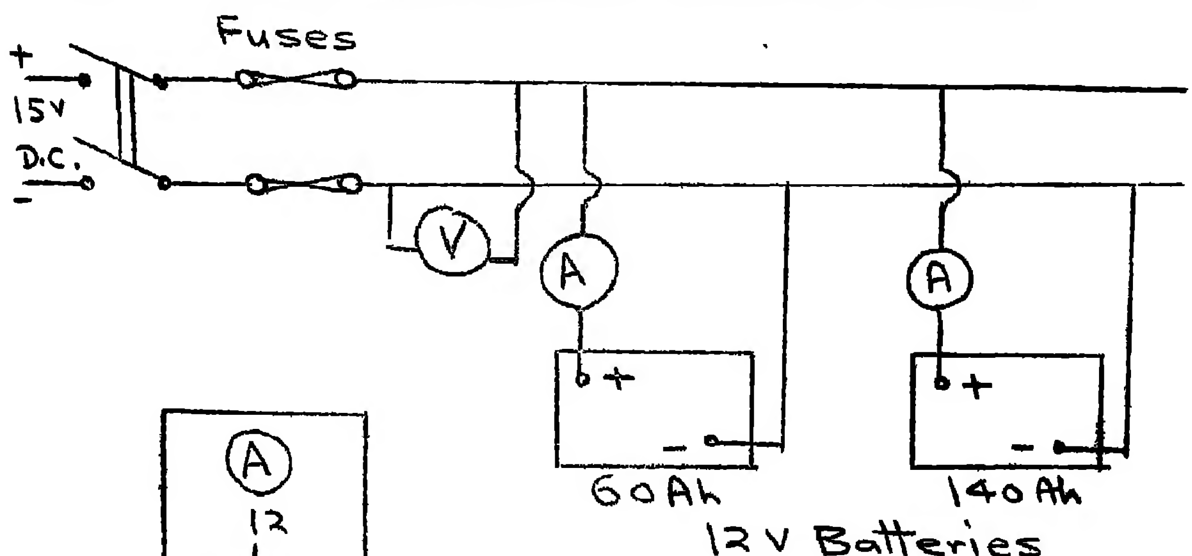
tester for ~~confirming the charge condition.~~ Close the vent plugs properly.

TABULAR RECORD OF OBSERVATION:

	Table I		Table II		
	Voltage per cell or whole battery	Specific gravity	Charging current	Duration of Charge	A. hr. capacity
Before charging					
After charging					

B. Constant-Voltage Charging:

Fig. 3: Circuit Diagram showing 2 batteries on charge



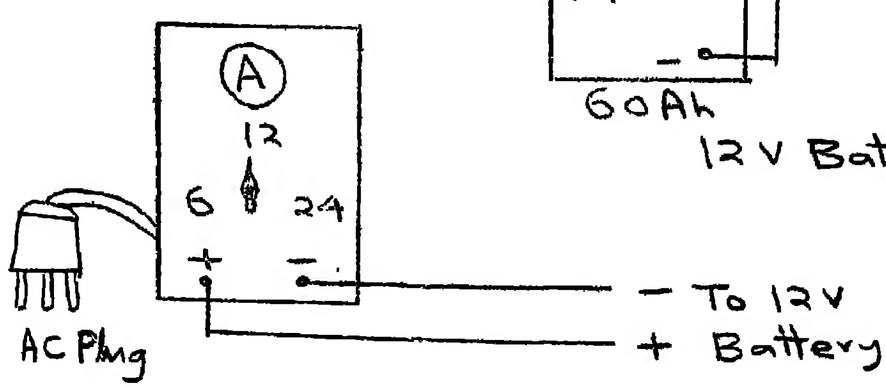


Fig. 4: Battery Charger

Procedure:

1. Clean the battery and its terminal posts.
2. Remove the vent plugs and check the electrolyte level.
3. Top up with distilled water (the level should be as marked on the battery or 1 to 1.5 cm above the top of the plate.

4. Measure the voltage of ~~each cell or whole battery and check the specific gravity of electrolyte in each cell.~~

5. Connect the battery to the charger after setting the correct viltage (on the charger it is indicated as 6v, 12v, 24v, etc.) Fig. 4

   Note:-Check for correct polarity.

   -There should be no loose connections.

   -In case of variable voltage source, adjust 2.5 to 2.65 volts per cell.

6. Record the charging current.

   (if charging current is high reduce the charging voltage)

7. Leave the battery in the circuit until it gets full charge.

   Note: No adjustment of current or voltage is necessary while in charge. The charging current tapers off to nearly zero when battery is fully charged.

   Charging current depends on charging voltage and amount of charge left in battery.

8. Disconnect the battery and test for its condition as stated in Step 10 of previous part.

9. Close the vent pluge.

TABULAR RECORD OF OBSERVATION:

Table I

	voltage per cell for the battery voltage	Specific gravity
Before charging		
After charging		

Table II

Charging current in Amperes	Duration of charge.(hrs)	Ampere hour capacity of battery

PRECAUTIONS :

1. Watch the temperature of the electrolyte (should not exceed 45° C)

2.

2. ~~Electrolyte is injurious, avoid coming in contact with it.~~ Wash with water if you come in contact or falls on your cloth.

3. ~~There must be no loose connections.~~

4. Naked flames should not be taken ~~near a battery~~ under charge.

5. Charging room should be well ventilated.

6. Do not short the battery terminals to test its condition.

7. Reduce charging current when bubling starts.

8. Apply petroleum jelly to battery terminals to avoid corrossion after putting it into service.

QUESTIONS FOR EVALUATION:

1. If 3 batteries of 40 Ah, 70 AH and 140 Ah are connected is series for constant current charge what should be the maximum charging current that can be used for 10 hr. charge?
2. What will happen if the battery is reverse connected (+ve of battery to -ve of supply and -ve to +ve)?
3. Name the Electrolyte used in lead acid batteries.
4. If you have to prepare electrolyte for the battery state how will you mix and what precautions are necessary.
5. One of the cell of a battery shows 1.5 v even after it was in charge for 10 hrs. What does this indicates?
6. The electrolyte level of a battery is too low due to accidental spill over. What will you add to make up the level?
7. How will you identify the +ve and -ve terminals of a battery if no marking is available on it?
8. Which is the sure test to know the charging condition of a battery?

REFERENCE:

1. Storage Batteries by G. Smith.
2. Industrial Electricity by C.L.Daws.

EXPERIMENT/PRACTICAL No.16

TITLE OF EXPERIMENT/PRACTICAL:

Visit to thermal power station.

SPECIFIC OBJECTIVES:

1. To be familiar with thermal power station.
2. To understand basic schematic layout of thermal power station.
3. To understand the function of basic equipment of thermal power station.

INTRODUCTORY INFORMATION AND RELATED THEORY:

In thermal power station the heat energy obtained by burning the coal is utilised to convert water into steam in a boiler. This steam is passed through the steam turbine converts heat energy into mechanical energy. The turbine acts as a prime-mover for the alternator. The turbine acts as a prime-mover for the alternator. The turbine supplies, mechanical energy to the alternator. Alternator converts mechanical energy into electrical energy.

The basic block diagram representation of steam power station is given in Fig.1.

In actual thermal power station these are many other axiliaries for its smooth operation.

Thermal power station requires ample quantity of water and coal. While selecting the site these factors are kept in mind.

EQUIPMENT AND MATERIAL:

Visit to thermal power station.

CIRCUIT DIAGRAM:

As given in Fig. 1 attached.

PROCEDURE:

1. Follow strictly the instructions given by the guide regarding safety measures.
2. Start your visit from coal handling plant.

~~Listen carefully the information given by the guide.~~

4. Tabular record of observations should be filled in the power station itself.

TABULAR RECORD OF OBSERVATIONS:

Observe the following:

a) Coal and ash handling plant:

1. Type of coal handling arrangement.
2. Quantity of coal used per month.
3. Is the coal pulverised?
4. Type of ash handling arrangement.
5. Disposal arrangement for ash.

b) Air and Gas Circuit:

1. Method of air heating.
2. Type of draft.
3. Basic function of a chimney.

c) Feed water and steam circuit:

1. Source of raw water.
2. Reason for water treatment.
3. Basic function of a boiler.
4. Type of boiler.
5. Pressure of outgoing steam.
6. Temperature of outgoing steam.
7. Basic function of a turbine.
8. Type of turbine.
9. Speed of turbine.
10. Pressure of the output steam in the turbine.
11. Basic function of a condenser.

d) Alternator (a.c. generator) - Exciter:

1. MVA/KVA output of the alternator.
2. Generation voltage.
3. Frequency.
4. Speed.
5. No. of poles.
6. Type of the alternater.

7. Physical dimension.

8. Type of excitation system.

9. Excitation voltage.

e) Control Room:

1. Name various types of relays used:

   i.

   ii.

   iii.

2. Measuring instruments:

S. No.	Name of the meter.	Basic Function	Reading at the time of visit.
1.	Ammeters.		
2.	Voltmeters.		
3.	Frequency meter.		
4.	Power Factor Meter.		
5.	Energy Meter		
6.			
7.			

f) Transformer:

1. KVA/MVA Rating.

2. Input voltage / output voltage.

3. Winding connection primary/secondary
   primary / secondary

4. Method of cooling.

5. Physical dimensions.

6. Basic function of:

   i. Transformer

   ii. Conservator

   iii. Breather

   iv. Buchholz's relay

   v. Transformer bushing.

PRECAUTIONS:

1. ~~Donot touch any equipment without permission.~~
2. Maintain safe distance from the various equipment.
3. Do not disturb normal working of the power station
4. Observe strictly the safety instructions.
5. Move alongwith your guide.

QUESTIONS FOR EVALUATION:

1. An alternator converts................

   energy into .... energy.

2. Why is the coal pulverised?
3. Name five main auxiliaries of the steam power station.
4. Mention the total installed capacity of the power

   station visited.

5. Is the alternator excitation a.c. or d.c.? Why?
6. What is the function of cooling tower/cooling fountain?
7. Thermal power station causes atmospheric pollution. Expl
8. Explain.
8. Mention the location of the following:

   a) Instrument Transformers.

   b) Circuit breakers.

   c) Relays.

REFERENCES:

1. A Course in Electrical Power by Soni -

   Gupta Bhatnagar.

2. Power Station Practice by M.V. Deshpande.

Circuit Diagram:

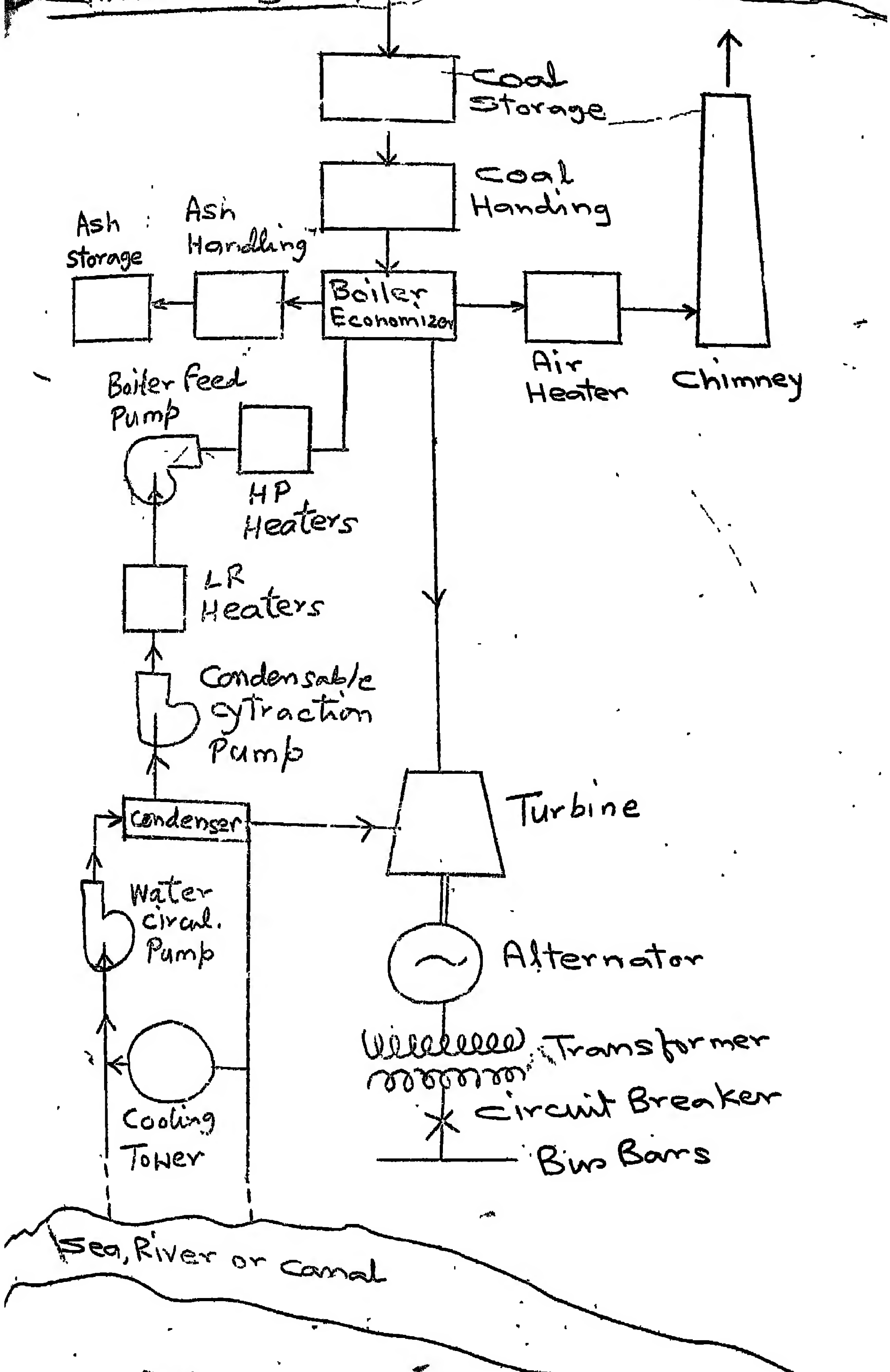


Fig: Line diagram of Thermal Power station

EXPERIMENT/PRACTICAL NO: 17

TITLE OF EXPERIMENT/PRACTICAL:

Digging of pits and holes.

Fixing of earthing plates.

Practice in different types of earthing.

Connections to lightening arrestors.

SPECIFIC OBJECTIVES:

1. To understand the necessity of earthing.
2. To study the types of earthing.
3. To learn the methods of earthing.
4. To test for proper earthing.
5. To study earthing of lightning Arrestors.

INTRODUCTORY INFORMATION AND RELATED THEORY:

The earthing is essential:

1. to save human life from danger of shock, death in case he comes in contact with charged frame (due to any fault, leakage current)
2. to maintain the line voltage constant
3. to protect large buildings from lightning.
4. to protect all machines, equipments and O.H. lines from lightning.
5. as a return path for electric traction.

The object of an earthing is to provide as nearly as possible a surface under and around the electrical installation, nearly at zero potential. The purpose of this is to ensure that in general all parts of appratus, other than live parts, shall be at earth potential.

Types of Earthing:

1. Pipe earthing (2) plate earthing (3) wire mesh or strip earthing (4) Rod earthing.

1) In pipe earthing a 2 m. long G.I.Pipe of 38 mm dia. is embeded vertically in ground to work as earth electrode. The depth at which the pipe is embeded depends upon the soil

condition. ~~The earth wires are fastened to the top section~~ of the Pipe above the ground level with nut and bolts. The pit area around the G.I.Pipe is filled with salt and coal mixture for improving the earthing. The pipe earthing is shown in Fig.I.

2) In plate earthing the earth wire is bolted effectively with the earth plate of copper (size 60 cm x 60 cm x 3.18 mm) or G.I. (size 60 cm x 60 cm x 6.3 mm) embeded 3 metres deep in the ground. Copper plates are found to be most effective earth electrodes and are not affected by the soil moisture. The earth wire is drawn through a G.I.pipe fitted with a cap on the top through which water is poured in the pit of earth plate from time to time for efficient earthing. This is shown in Fig.2.

3). In horizontal strip or wire mesh earthing wires or strips of copper or galvanized iron in the form of a mesh are embeded in the ground at a depth of 50 cm. The strips or wires mesh are laid parallel to each other at about 1 metre spacing and 0.5 metre below the ground level.

4). In rod earthing solid rods of 12 mm to 19mm dia. of copper or G.I. and of suitable length are buried in ground either by manual or pneumatic hammer. The effectiveness of the earthing increases with the increase of the length embeded rod.

For efficient earthing it is essential to pour salt water in the pit from time to time.

Earthing should be provided to the following:

1. Installations in buildings.
2. Domestic fittings and appliances.
3. Industrial Premises.
4. Electrically driven M/C tools.
5. Electric arc welding equipment.
6. Industrial electronic apparatus.
7. Electro-Medical Apparatus.

8. ~~Substations, and generating stations.~~

9. Over-head power lines.

10. Neutral wire of A.C. Supply System.

11. Middle wire of the three wire D.C. distribution system.

The resistance of the earthing system depends upon the following factors:

1. Soil condition. It should be:

   i. Wet marshy ground and grounds containing refuse, such as ashes, cinders and brine waste, or

   ii. Claying soil or loam mixed with small quantity of sand, or

   iii. Clay and loam mixed with varying proportions of sand, gravel and pebles or

   iv. Damp and Wet Sand Pit.

2. Temperature of soil,

   If temperature of soil is expected to be quite low, the earth electrodes should be installed well below the frost line.

3. Waste contents of the soil, resistivity of soil increases very abruptly with the decrease in moisture contents

4. Spacing and size of electrodes, Resistivity decreases with increase in size of electrodes.

5. Depth at which the electrodes are embeded; Resistivity decreases with increased depth of embedding.

6. Nature of loop wire i.e. material of conductor. Copper plates are found to be most effective earth electrodes as they are not rusted by the soil moisture. But on account of its high cost, G.I. is preferred for normal work.

Measurement of earth resistance:

In this method two auxiliary earth electrodes, are placed at suitable distances from the test electrode (See Fig. 63). A measured current is passed between

electrode 'A' to be ~~tested and an auxiliary current electrode~~ 'C' and ~~then potential difference~~ V between the electrode 'A' and the auxiliary potential electrode 'B' is measured. The resistance of the test electrode 'A' is given by :

$$R = \frac{V}{I}$$

Where R = Resistance of the test electrodes in Ohms.

V = Reading of voltmeter in volts

I = Reading of Ammeter in Amps.

It is important to note that the resistance of earth system shall not be more than 1.0 Ohms.

Earthing of Lightening Arrestors:

The bases of lightening arresters shall be directly connected to the earth by conductors as short and as practicable to ensure minimum impedance. There shall be a direct connection from earth side of the lightening arresters to the frame of the apparatus being protected. The earth connection should not pass through iron pipes as it would increase the impedance of the connection.

EQUIPMENT AND MATERIALS:

i) For Pipe Earthing:

1. G.I.Pipe 38 mm ϕ 2.5m long.
2. Reducing Socket 38 x 19 mm.
3. G.I.Pipe 19mm ϕ 1m long.
4. G.I.Nut, washer, check nut.
5. Funnel, wire mesh.
6. G.I.cover hinged with C.I.Frame.
7. G.I.Pipe 12. 7 mm 80 cm long. 12.7mm
8. Charcoal and Salt.
9. Cement concrete (1:4:8)

ii) For Plate Earthing:

1. G.I.Plate 60 x 60 cm x 6.30 mm.
   OR
2. Copper plate 60 mm x 60 cm x 3.18 mm.

3. G.I. Pipe 12.7 mm φ 1.5m long.
4. Copper or G.I.Wire.
5. G.I. Pipe 19 mm φ 1.5 m long.
6. C.I. Cover hinged with CI frame.
7. ~~Funnel with wire mesh.~~
8. Cement concrete (1:4:8)
9. Earth digging equipments.

CIRCUIT DIAGRAM:

Given on separate sheets.

PROCEDURE:

A) Earthing Methods

1. Mark on the ground where earthing is to be done as per requirement.
2. Take the digging equipments and make a way/house for earthing plate/pipe as the case may be upto the required depth.
3. Put the layer of charcoal and salt and then place plate/pipe vertically. But again the layers of charcoal and salt to cover plate/pipe. Ensure that earthing wire, pipe of funnel and pipe carrying earthing wire are attached properly with plate/pipe.
4. Put the Funnel at the top of funnel pipe with wire mesh.
5. Concrete the area around the funnel and put C.I frame with C.I cover on it.
6. Pour sufficient amount of water through funnel, after solidifying concrete, for ensuring good earthing.
7. Connect earth wire taken out through pipe/plate to the equipment to be earthed.

(B) Measurement of earth Resistance:

1. Take 3 electrodes, one as test electrode, other as potential electrode and third as current electrode. The electrode should be 12.5mm ϕ and 1.25m long and made of mild steel.

2. Put the electrodes, as shown in fig '3', in the ground. The distance between Electrode A&C vary from 30m to 50m. The electrode B should be put in between. The electrodes should be driven upto one metre into the ground.
3. Connect ammeter and voltmeter as shown.
4. Connect current source at power frequency of 50 Hz.
5. Record the emeter reading.
6. Repeat the meter readings by varying distance between Electrode 'A' & 'C' from 30m to 50m. record two more readings.
7. Calculate earth resistance and record it.

TABULAR RECORD OF OBSERVATION:

S. No.	Distance between electrodes A&C	Voltmeter Reading in Volts	Ammeter Reading in Volts	Resistance in Ohms R $\frac{V}{I}$
1.				
2.				
3.				

PRECAUTIONS:

1. The earthing electrodes should be situated within ..ꟷ from the building whose installation system is being earthed.
2. The size of continuous earth wires used with cables should not be less than 14 SWG.
3. Loose earth or coal salt mixture should be filled around the earth electrode for effective earthing.
4. The size of the earth wire run for earthing should be able to carry the full load current of installation

offering least resistance to the flow of leakage current.

QUESTIONS FOR EVALUATION:

1. Why earthing is essential?
2. State types of earthing.
3. Illustrate by a neat diagram the different methods of earthing.
4. How will you earth the lightning arrester?
5. State permissible value of earth resistance of earth systems?

REFERENCES:

1. Code of Practice for Earthing.
   IS : 3043 : 1966
2. Specification for Earthing Transformer.
   IS : 3151 : 1965
3. Code of Practice for Electrical Wiring Installations.
   IS : 732 : 1963
4. Electrical Wiring & Practicals.
   by A.B. Dass.

METHODS OF EARTHING

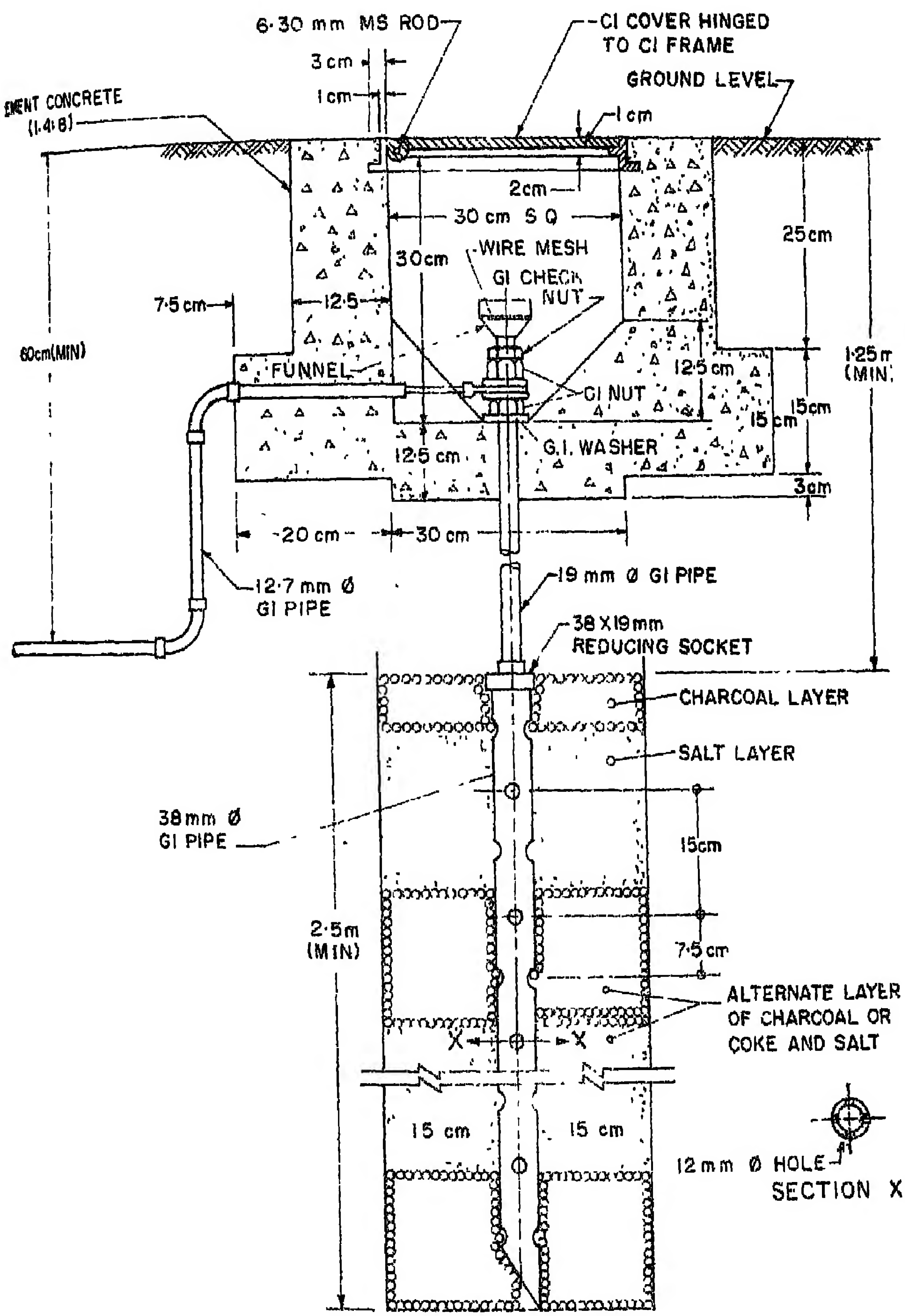


Fig 17·1

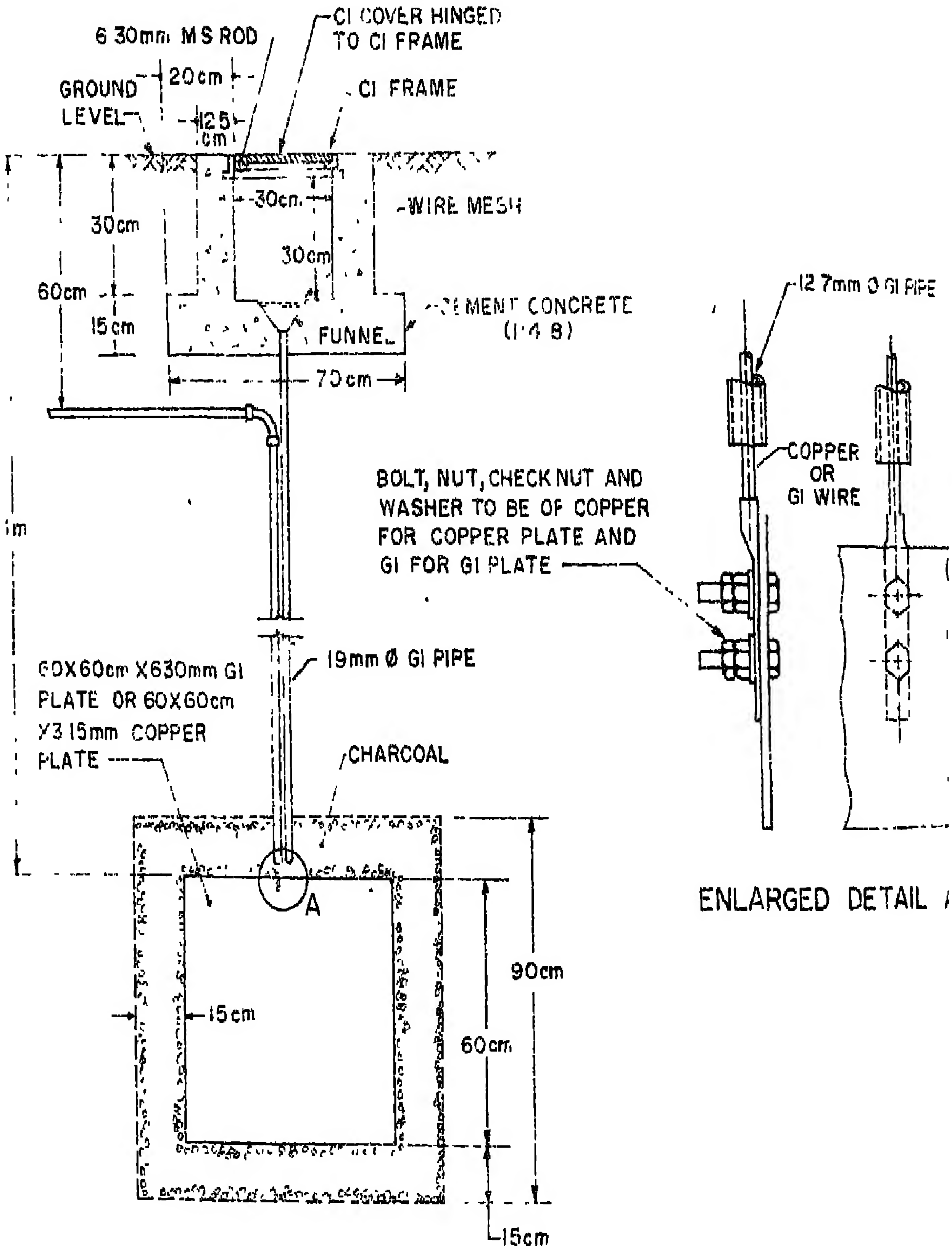

6 30mm MS ROD
CI COVER HINGED TO CI FRAME
GROUND LEVEL
20cm
12.5 cm
CI FRAME
30cm.
WIRE MESH
30cm
30cm
60cm
15cm
CEMENT CONCRETE (1:4 8)
FUNNEL
70cm
12.7mm Ø GI PIPE
COPPER OR GI WIRE
BOLT, NUT, CHECK NUT AND WASHER TO BE OF COPPER FOR COPPER PLATE AND GI FOR GI PLATE
19mm Ø GI PIPE
60X60cm X630mm GI PLATE OR 60X60cm X3 15mm COPPER PLATE
CHARCOAL
A
ENLARGED DETAIL
90cm
15cm
60cm
15cm

Fig 17·2

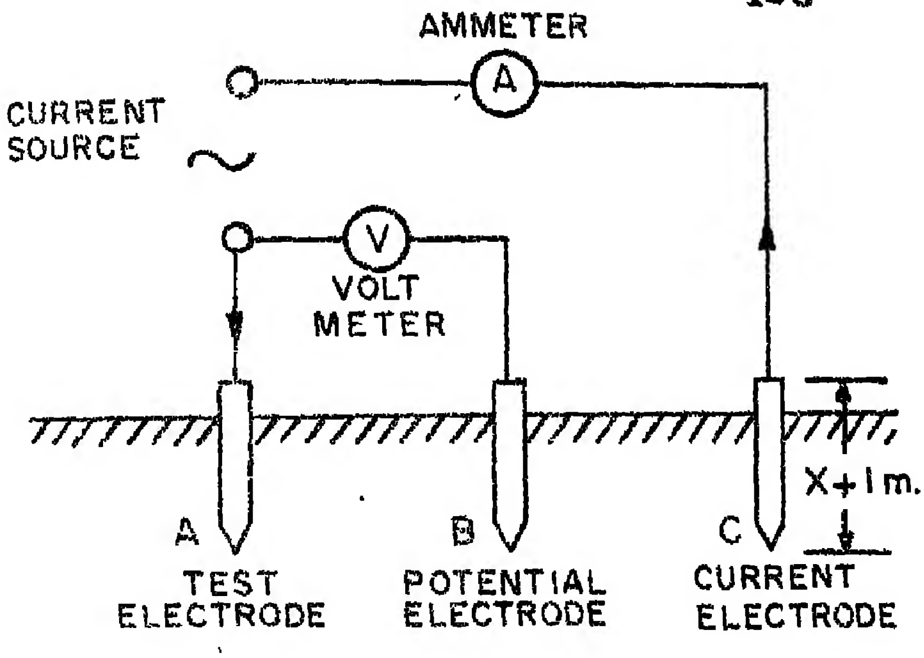

AMMETER
A
CURRENT
SOURCE
V
VOLT
METER
X+1m.
A
B
C
TEST
ELECTRODE
POTENTIAL
ELECTRODE
CURRENT
ELECTRODE

Fig 17·3

EXPERIMENT/PRACTICAL No: 18

TITLE OF EXPERIMENT/PRACTICAL:

Visit to different installations and observing earthing requirements.

SPECIFIC OBJECTIVES:

1. To be familiar with the earthing requirements of different installations.
2. To study various methods of earthing used at different installations.
3. To be able to draw the diagrams of earthing provided at different installations.

INTRODUCTORY INFORMATION RELATED THEORY:

An electric installation is always provided with earthing. Earthing provides a path of least resistance to the leakage current.

The different types of earthings provided with installations are:

1. Pipe earthing generally used at the rocky area.
2. Plate earthing. This is used for areas other than rocky area.
3. Horizontal wire or strip earthing. This type of earthing is used if strips are to be buried in trenches or ditches at a depth more than 0.5 meter.
4. Rod earthing. This is used for testing earth resistance.

The earthing lead is connected between the earth point provided and the electrical installations. The earthing leads are of copper, aluminium or G.I. Generally two earthing leads are carried together and connected in parallel for effective earthing.

EQUIPMENT AND MATERIALS:

Different electrical installations.

CIRCUIT DIAGRAM:

The typical diagram of Fig.1 shows earthing arrangements for an outdoor substation. The circuit diagrams of earthing of the various installations are to be drawn at the time of visit.

PROCEDURE:

1. Visit the different installations and observe earthing requirements
2. Note down observations in the tabulated form.

TABULAR RECORD OF OBSERVATIONS:

Note down following information:

1. Type of installations.
2. Type of earthing provided.
3. Material used for earthing.
4. Dimensions of the earthing.
5. Resistance of the soil.
6. Resistance of the earth electrodes.
7. Material of earthing lead.
8. Size and shape of earthing lead.
9. Location of earthing.
10. Maintenance of earthing.
11. Whether neutral is earthed or not?
12. Whether earthing is provided for:
    i. Power Circuit.
    ii. Lighting circuit.
    iii. Substations.
13. Whether earth fault protecting device is provided or not?
14. Type of earth fault protecting device used.
15. Any other additional information.
16. Draw a diagram for earthing arrangement of the installation visited.

PRECAUTIONS:

1. Observe strictly the instructions given by the guide.
2. Note down the correct data in consultation with the guide

QUESTIONS FOR EVALUATION:

1. Which type of installations have you visited?
2. Which type of earthing is provided?
3. What is the material used for earth electrodes and earthing leads?
4. Discuss the maintenance procedure of earthing followed in the installation visited.

REFERENCES:

1. IS Code practice for earthing
   IS:3043:1966
2. IS Code practice for electrical wiring installations
   IS: 732:1963
3. Electrical wiring.
   by Arora
4. Newnes Electrical Pocket Book.

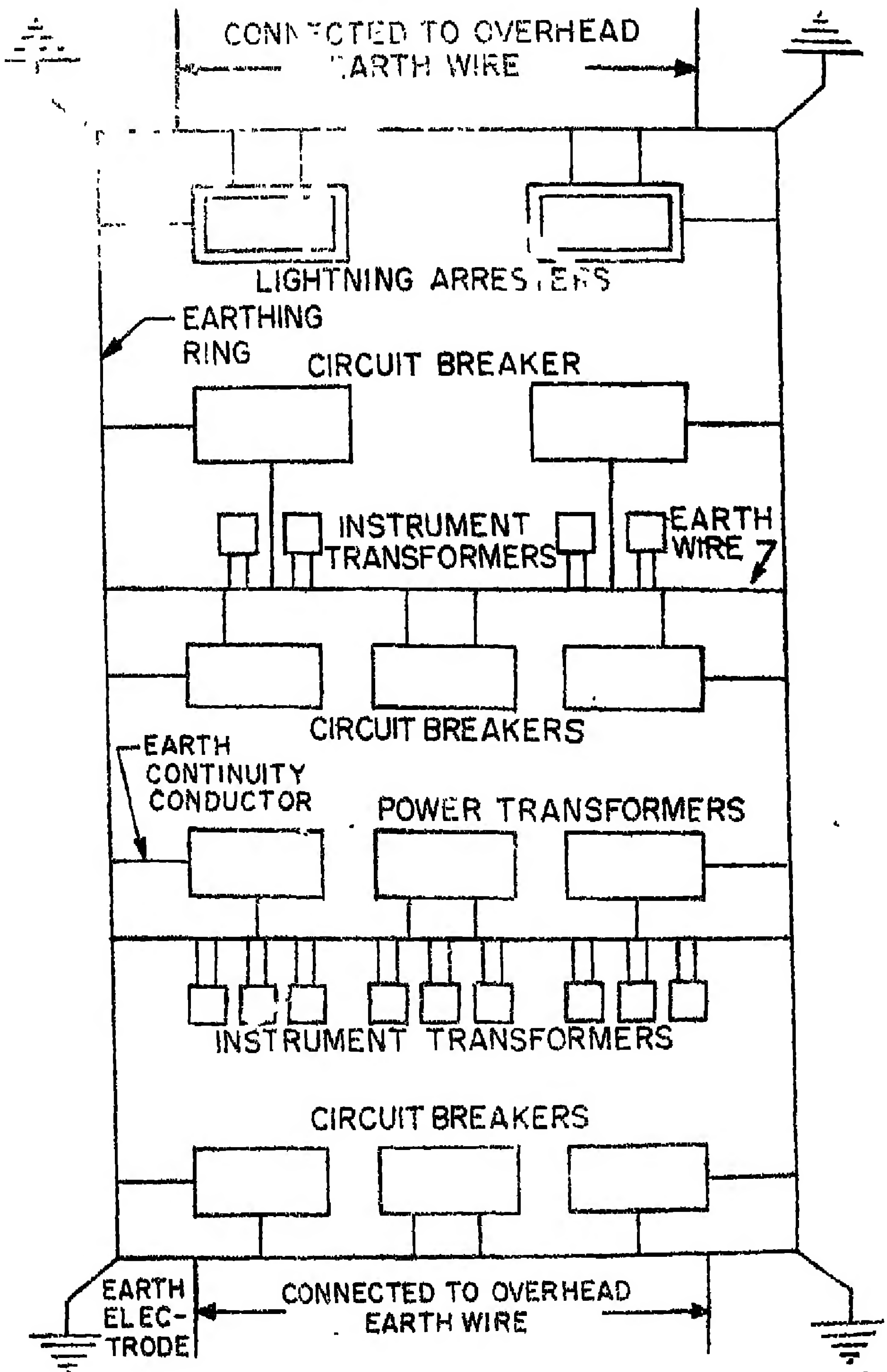

CONNECTED TO OVERHEAD EARTH WIRE
LIGHTNING ARRESTERS
EARTHING RING
CIRCUIT BREAKER
INSTRUMENT TRANSFORMERS
EARTH WIRE
CIRCUIT BREAKERS
EARTH CONTINUITY CONDUCTOR
POWER TRANSFORMERS
INSTRUMENT TRANSFORMERS
CIRCUIT BREAKERS
EARTH ELECTRODE
CONNECTED TO OVERHEAD EARTH WIRE

Fig 18·1

EXPERIMENT/PRACTICAL NO:19

TITLE OF EXPERIMENT/PRACTICAL:

1. Measuring continuity in earthing circuits.
2. Practice of earthing a given equipment.

SPECIFIC OBJECTIVES:

1. To understand the necessity of continuity of an earthing circuit.
2. To study the different methods to measure continuity in earthing circuit.
3. To connect/provide earthing to a given equipment.

INTRODUCTORY INFORMATION AND RELATED THEORY:

All the earthing conductors should be tested for their effective continuity. In case of an earth fault, poor or no earth continuity leads to fire hazard or shock to the persons who come in contact with the body of the machine or metal frame of the installation. In the absence of proper earthing current may pass through the body of the person causing shock. The proper earth connection will bypass the leakage current to earth and it will not pass through the human body (being a high resistance path).

Following are the tests to measure continuity of earthing circuits:

1. Alternating Current Test:

Earthing conductor together with conductor of known resistance is used for this test.
An a.c. voltage not exceeding 40 volts is applied at rated frequency of 50 Hz Current of 1.5 times (approximately) the rating of circuit under test is passed through the loop. Maximum current passed is about 25 Amps. The impedence of earth continuity conductor should not exceed one Ohm. The impedance should not be more than, 0.5 ohms for conduit wiring and 1.00 ohm for other types of wiring. Hand neon tester may be used as test equipment.

2. Earth Loop Impedance Test:

The total impedance of the loop should be such that it allows a large current (three times the rated current) to flow in the event of fault, to operate the protective device and ensure that rise in potential of metal of system does not take place. The total impedance is measured between consumer's earth terminal and earthing wire.

If fuse (HRC or Rewireble type) rating is of 30 Amps. with 240 volts, 50 Hz a.c. supply, then fault Current = 30 x 3 = 90 Amps. (minimum value expected).

Loop impedance = $\frac{240}{90}$ = 2.66 ohms.

If circuit brakers (C.B) are used for 150 A-circuits with 240 volts 50 Hz supply, then

Fault Current = 1.5 x 150 = 225 Amps. (Minimum value expected)

Loop impedance = $\frac{240}{225}$ = 1.06 Ohms.

Earth loop impedance test can be carried in the following ways:

(a) Line Earth loop

(b) Neutral Earth loop

Earth loop impedance tester is an instrument used for this test. This instrument passes a short duration current through the loop, the value of current depends upon the value of impedance of loop and voltage of the tester. The current passes through 10 ohm resister in series with the loop and the potential difference across which is measured by an instrument calibrated to read loop impedance directly. The instrument incorporates a voltmeter and a voltage selector switch enabling it to use on supplies of different line voltages (Refer Fig. 5).

EQUIPMENT AND MATERIALS:

1. Low volts a.c. supply power pack.
2. Voltmeter a.c. low range.
3. Ammeter a.c. suitable range.
4. Earth point at consumer's premises.
5. Plug socket with earth connection.
6. Earth point
7. Machine to be earthed.
8. Earth loop impedance tester.

CIRCUIT DIAGRAM:

Fig. 1,2,3,4 & 5. are drawnon separate sheets.

PROCEDURE:

1. Take a power pack having low a.c. supply volts range.
2. Connect the terminals of power pack with earth point of plug socket and earth point through ammeter as shown in Fig. 1.
3. Connect the Voltmeter in the circuit also.
4. Calculate impedance with the help of formula $Z=\frac{V}{I}$ it should not exceed one ohm.
5. Similarly carry out line and neutral earth loop impedance test (Ref. Fig 2 and 3).
6. Record the results of each test in a tabulated form.
7. Take the given electric machine.
8. Install it at required place.
9. Take an earth lead and one end of it is to be connected to the consumer's earth point, where-as other one to the earth point of the given machine.
10. Test for proper earthing.

TABULAR RECORD OF OBSERVATION:

Sl. No.	Type of test	Voltmeter Reading	Ammeter Reading	Impedance
1.	Alternating Current Method			
2.	Line earth loop impedance test.			
	i) Ist position of 'P' switch			
	ii) IInd position of 'P' switch			
3.	Neutral Earth loop impedance test.			
	i) Ist position of 'P' switch			
	ii) IInd position of 'P' switch			

PRECAUTIONS:

1. Low volt a.c. power pack is to be selected for test.
2. Use instruments of proper range.
3. Make use of neon tester whenever required.

QUESTIONS FOR EVALUATION:

1. What is the necessity of measuring continuity in earthing circuit?
2. Name the various methods to measure continuity in earthing circuit?
3. Describe with suitable illustration any one method to measure continuity in earthing circuit.
4. What precautions you would observe while earthing a given equipment?
5. Draw a circuit diagram of earth loop impedance tester.

REFERENCES:

1. IS Code practice for earthing.

IS : 3043 : 1966

2. IS Code practice for electrical wiring installations (System voltage not exceeding 650 volts)

IS : 732 : 1963.

3. Newnes Electrical Pocket Book.

4. Electric Wiring Arora.

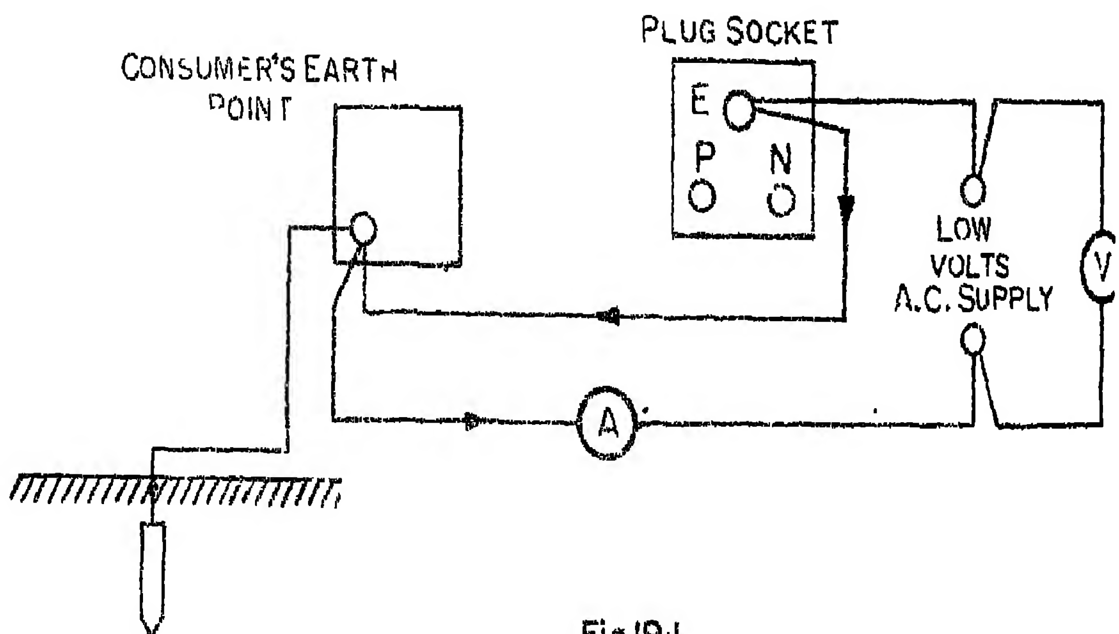
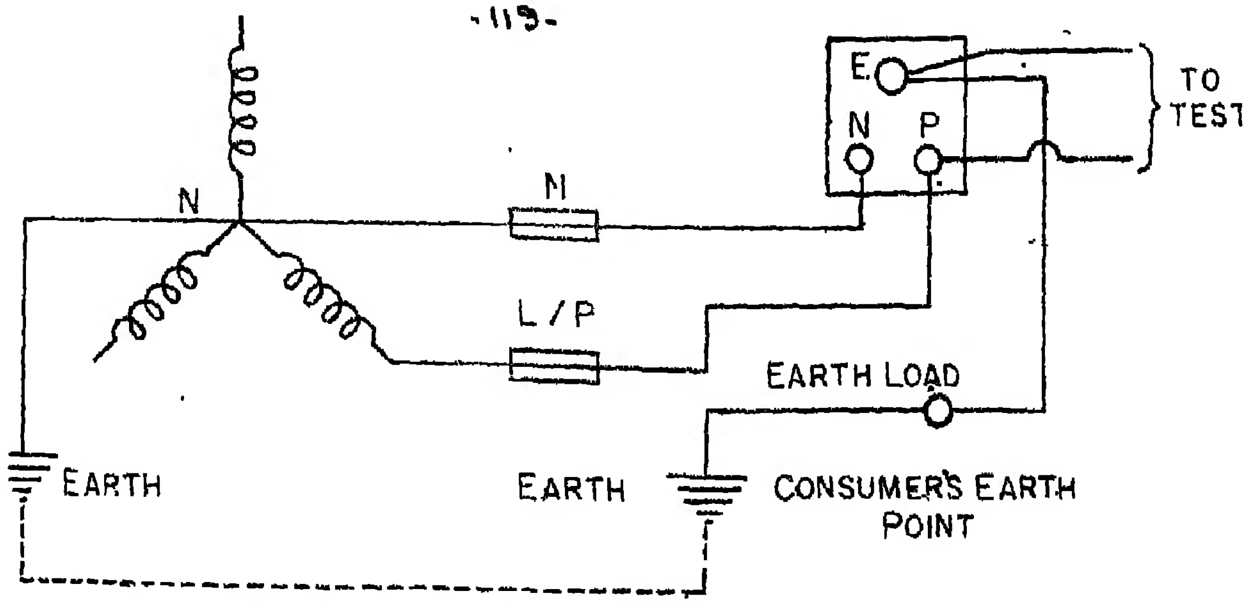

PLUG SOCKET
CONSUMER'S EARTH POINT
E
P
N
LOW VOLTS A.C. SUPPLY
V
A

Fig 19·1



E
N
P
TO TEST
N
N
L / P
EARTH LOAD
EARTH
EARTH
CONSUMER'S EARTH POINT

Fig 19·2

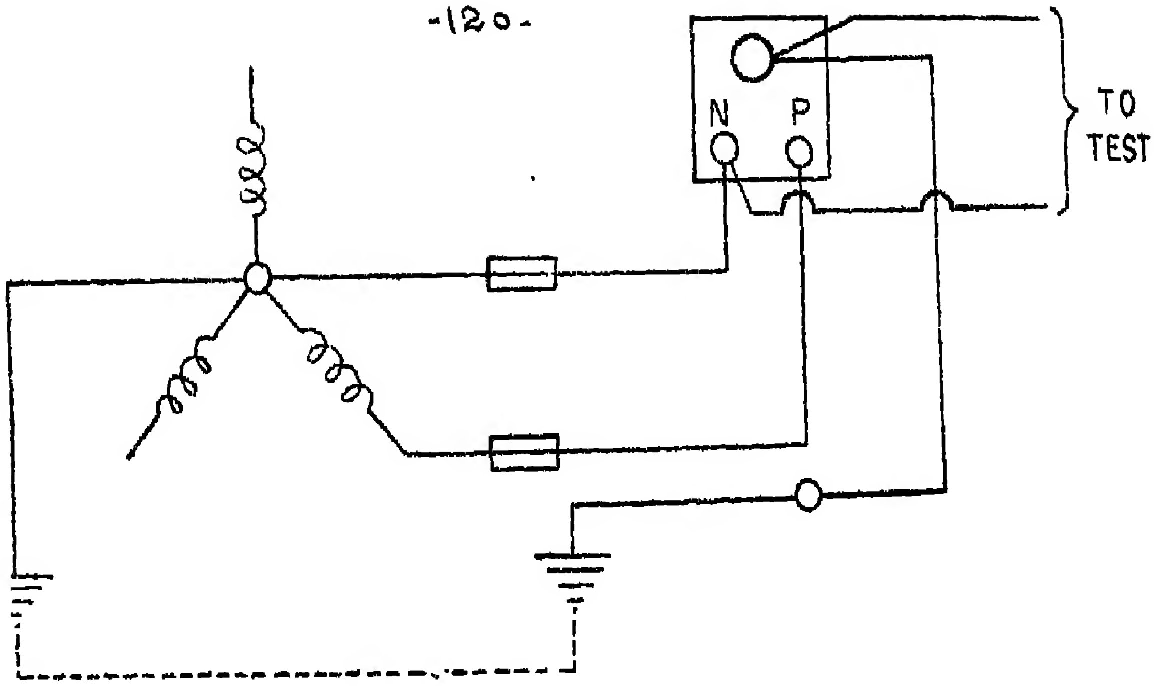
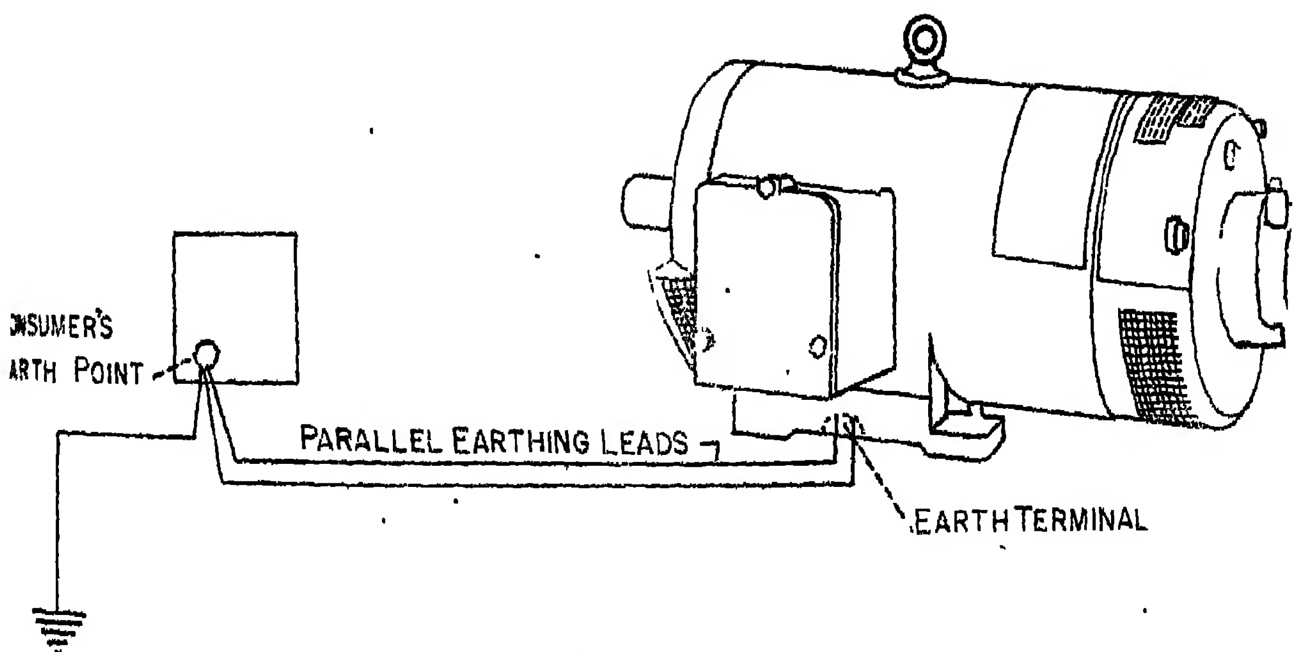


Fig 19·3



ONSUMER'S
ARTH POINT
PARALLEL EARTHING LEADS
EARTH TERMINAL

Fig 19.4

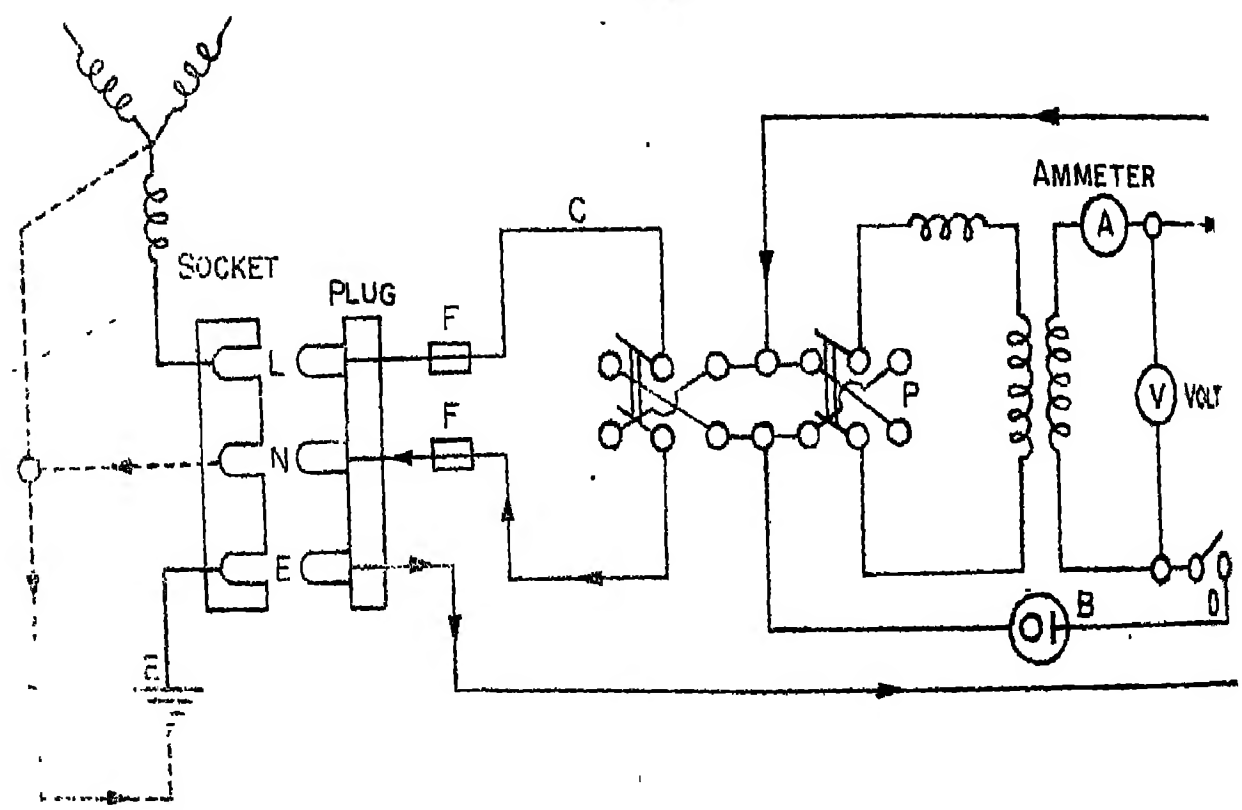


Fig 19·5

EXPERIMENT/PRACTICAL No. 20

TITLE OF THE EXPERIMENT/PRACTICAL

Visit to sub-stations and to prepare schemetic circuit-diagrams.

SPECIFIC OBJECTIVES:

1. To be familiar with the various functions of a substation.
2. To be familiar with the various equipment in a substation.
3. To be able to draw schematic circuit diagram of a substation.

INTRODUCTORY INFORMATION AND RELATED THEORY:

A substation is defined as an assembly of equipment which are installed to perform any one or more of the following basic operations:

i. Switching.
ii. Changing of voltage level.
iii. Power factor correction.

Suggestions are of following types:

i) Indoor type   ii) Outdoor type.

(i) Indoor type:- In this type of substation the apparatus is installed with in a substation building. Such substations are usually for the voltages upto 11 KV. These substations are used at locations where the surrounding atmosphere is polluted with impurities such as gases, fumes etc.

(ii) Outdoor substation:- In such substations the apparatus is installed in the open yeard outside the control room. Outdoor substations are of two main types:-

(a) Pole mounted type:- Such substations are erected for the distribution of power in the localities. Single-pole or H-pole or 4-pole structures with suitable plateforms are employed For transformers upto capacity of 200 KVA.

(b) Foundation Mounted substation: Such substations are erected for transformers above 200 KVA capacity and voltages of 33KV and above.

vc.

EQUIPMENT AND MATERIALS:

Visit to a substation.

CIRCUIT DIAGRAM:

The student is required to prepare the complete layout of the substation actually visited. The layout of a typical substation is shown in Fig.(1).

(Note: The figures is only for illustration. The arrangement in the substation visited may be different).

PROCEDURE:

1. Follow strictly the instructions given by the guide regarding safety measures.
2. Start your visit from the incoming end.
3. Listen carefully the instructions given by the guide.
4. Tabular record of observations should be filled in the substation itself at the time of the visit.

TABULAR RECORD OF OBSERVATION:

(A) Incoming system.

1. Incoming voltage.
2. Is there any lightning arrester at the incoming end? Yes/No.
3. No. of incoming circuits.
4. Route of the incoming supply.
5. Height and type of the tower.
6. Type of the conductor used.
7. Type of the insulator.
8. No. of discs in an insulator string.
9. Repeat information (1) to (8) for outgoing line.

(B) Bus bar arrangement.

1. Type of the busbar.
2. Material of the busbar.
3. Busbar protection if any. Yes/No
4. Isolaters (a) Manually operated

   (b) Motor operated
5. Type of the circuit breakers.

(C) Instrument transformers:

(i) C.T. - primary current.
- secondary current.
- primary no. of turns.
- Rating

(ii) P.T. - Primary voltage.
- Secondary voltage.
- Rating.

(D) Transformer

1. Power/distribution transformer.
2. Rating of the transformer.
3. Primary/secondary voltage.
4. type of cooling
5. transformer protection
6. winding connections

(E) Battery room

1. No. of batteries.
2. Total voltage.
3. Charging arrangement
4. Ampere-hour capacity.

(E) Control Room

(a) Name of the various types of relays
(b) Various types of instruments provided.

(G) Miscellaneous:

1. Is there any compressor room?
2. Is there any oil testing equipment?
3. Type of earthing arrangement.
4. Is PLCC provided?
5. Any arrangement for power factor improvement?
6. List various equipments used in the substation.

(H) Make the complete circuit diagram of the substation layout.

PRECAUTIONS:

1. Observe strictly the safety instructions.
2. Move along with your guide.
3. Donot touch any equipment without permission.
4. Keep a safe distance from the various equipment.

QUESTIONS FOR EVALUATION:

1. Is there any relationship between the system voltage and the number of insulator discs?
2. What is the function of the trenches provided in the yard?
3. Explain the functions of a substation.
4. Why lightning arrester is used.
5. Why end tower is different than the other towers?
6. Draw the sketch of string insulator.

REFERENCES:

1. A course in Electrical Power by Soni, Gupta and Bhatnagar.
2. Electrical Technology by J.B.Gupta.

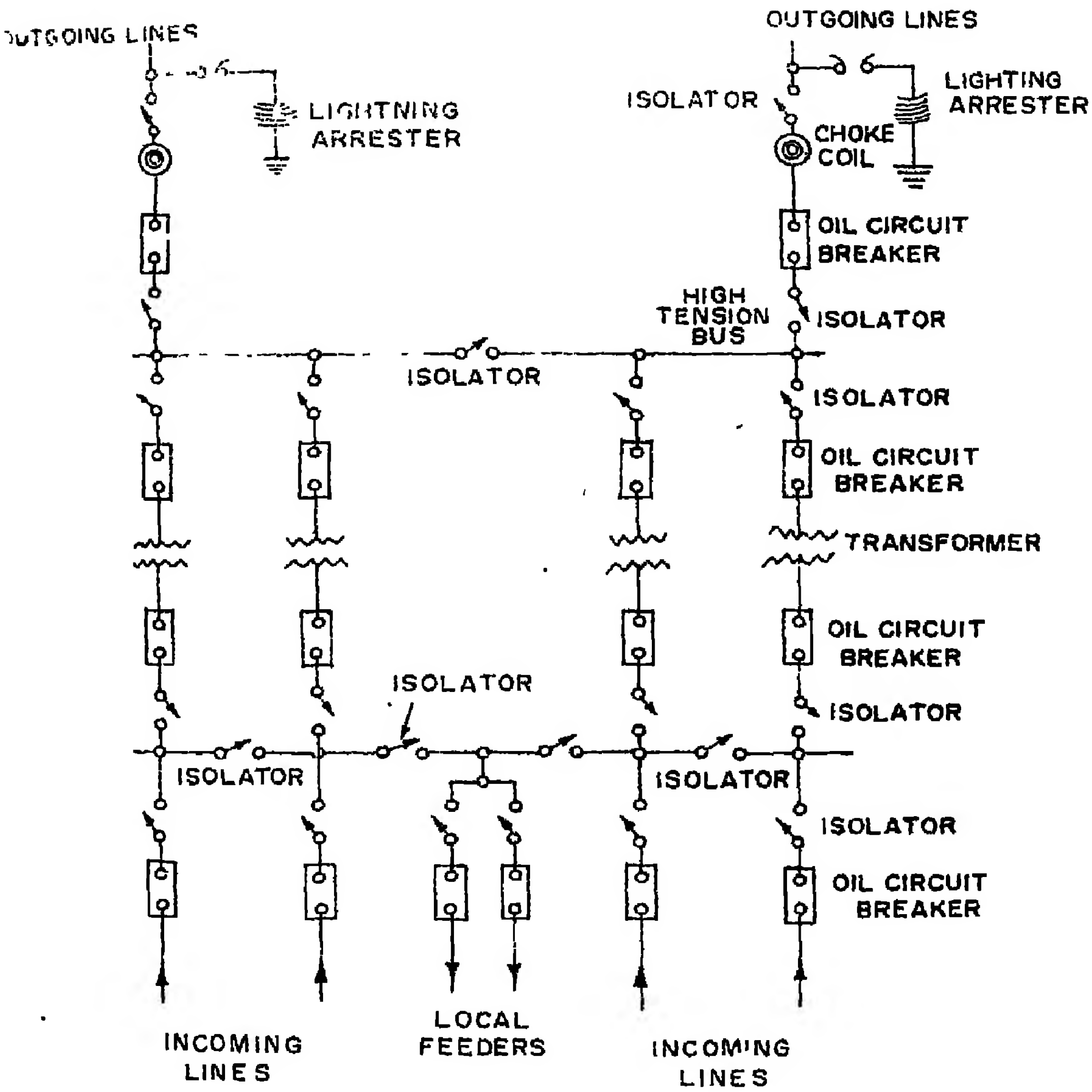

OUTGOING LINES
LIGHTNING ARRESTER
OUTGOING LINES
ISOLATOR
LIGHTING ARRESTER
CHOKE COIL
OIL CIRCUIT BREAKER
HIGH TENSION BUS
ISOLATOR
ISOLATOR
ISOLATOR
OIL CIRCUIT BREAKER
TRANSFORMER
OIL CIRCUIT BREAKER
ISOLATOR
ISOLATOR
ISOLATOR
ISOLATOR
ISOLATOR
OIL CIRCUIT BREAKER
INCOMING LINES
LOCAL FEEDERS
INCOMING LINES

Fig 20·1

EXPERIMENT/PRACTICAL No.21

TITLE OF THE EXPERIMENT/PRACTICAL:

Display of AC Wave form by an Oscilloscope.

SPECIFIC OBJECTIVES:

1. To learn how to use controls on the pannel of the Oscilloscope.
2. To use Oscilloscope for visual display of electrical signals.

INTRODUCTORY INFORMATION AND RELATED THEORY:

The Cathode Ray Oscilloscope is a very useful laboratory instrument for measurement and analysis of wave-forms in electronic circuits. An oscilloscope can present a visual display of current/voltage changing with time on its screen.

The heart of the device is a Cathode ray tube (C.R.T.). The filament heats the Cathode and cathode emits electrons. The emitted electrons pass through the electron gun to form an electron beam. Intensity of the beam acceleration of electron and focussing of beam to sharp point are the activities controlled by electron gun.

Electrostatic Defection System uses two pairs of parallel plates. One pair of plates is put in vertical position where as the other pair is put in horizontal position. Deflection is produced by voltages applied to these plates. Time base voltage is applied to produce horrizontal deflection, The signal under test produce vertical deflection. Screen is coated with a chemical called 'PHOSPHOR' which emits light when electron beam strikes the screen.

There is no light when the beam is cut off. A general purpose Oscillosopo as shown in Fig. 1 has the following controls:

1. FOCUS

This is adjusted to give a sharpest trace on the screen.

2. INTENSITY

This is the brightness control which is adjusted for the desired brightness of the trace.

3. HORIZONTAL SHIFT AND VERTICAL SHIFT

These shifts apply bias voltages, to horizontal and vertical plate and bring the trace to the desired positions.

4. VERTICAL RANGE MULTIPLIER OR SELECTOR

This is a calibrated step attenuator which selects the verticle input from voltage divider. It controls the extent of vertical deflection of the beam.

5. VERTICAL GAIN

This is a Potentimeter which provides control to the ampletude of the signal fed to vertical plates.

6. HORIZONTAL GAIN

There is a potentiometer which provides continuous control of the amplitude of the signal connected to the horrizontal Amplifier.

Coarse and fine frequentcy control: Coarse frequency control is a Rotary selector switch which determines the frequency range over which the sweep of the time base Oscillator may be adjusted. Fine frequency control adjusts sweep frequency to a desired value.

7. SYNCHROMISING SELECTOR

This is a Rotary switch which selects either Internal, External or line syncroniging.

8. SYNCHRONIZING AMPLITUDE

This is a potentiometer which varies the level of synchronizing pulse. This control should be set at a lowest level at which it will lock the signal.

9. ON/OFF SWITCH

This is a switch to apply Mains Power supply to the Oscilloscope. It is usually with the intensity control.

10. INPUT JACKS AND TERMINALS

Vertical input and ground. These are used for input signal voltage whose waveform is to be observed.

11. HORIZONTAL INPUT AND GROUND

These terminals are used for external deflection voltage as a substitute for internal sweep voltage.

12. EXTERNAL SYNCHRONIZING TERMINAL

This is used for external synchronization.

13. TEST SIGNAL

This jack supplies normally a standard voltage of one volt peak to peak for calibrating the Oscilloscope for AC voltage measurement.

14. INTENSITY MODULATION ('Z' axis Modulation)

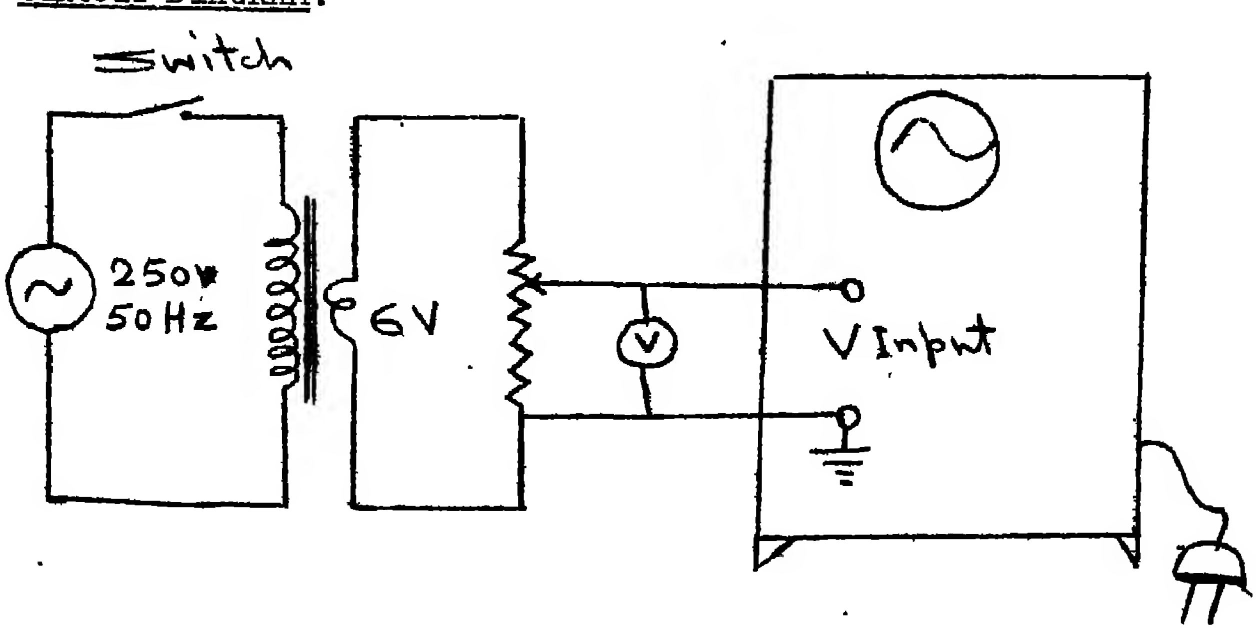
This jack accepts a signal for grid or cathode of the CRT for intensity modulation of the beam.

All the above mentioned operating control are shown in Fig. No.1

EQUIPMENT AND MATERIALS:

1. General purpose Oscilloscope - one
2. Step down Transformer 230 6 v - one
3. Suitable rheostat to be used as potentiometer.
4. 0-10V AC Voltmeter

CIRCUIT DIAGRAM:



PROCEDURE:

1. Connect the circuit as shown in the figure.
2. Wait a minute after putting the supply on for warming up of the Oscilloscope.
3. Adjust the intensity control and fussing, control to get a fine spot on the screen.
4. Adjust the variable resistance to give above 2 volts on the meter.
5. Adjust vertical range and vertical gain control to keep the amplitude with in limits of the screen.
6. Adjust the time base Oscillator frequency so that the wave shape is nearly steady.
7. Select internal sync by sync selector.
8. Adjust level of internal synchronizing pulses to lock the time base frequency and keep wave shape steady.
9. Trace the shape of wave form from the screen of C.R.O. on a Tracing Paper.
10. Change the input voltage to .5 V 1 V, 1.5V and repeat steps 1 to 9.
11. Record different wave shape against input voltage in the following proforme:

TABULAR RECORD OF OBSERVATION

S.No.	Input Voltage	Wave Shape
1.	0.5 V	
2.	1 V	
3.	1.5 V	
4.	2 V	

PRECAUTIONS:

1. Avoid connecting the line point to the ground lead of the Oscilloscope.
2. Use isolation transformer to avoid short circuit.
3. Do not connect excessively high voltage beyond rated value at the vertical input terminals.
4. Apply rated mains supply voltage for the C.R.O.
5. Do not keep intensity too high. This may damage the screen material.

QUESTIONS FOR EVALUATION:

1. What is the function of frequency control on the panel.
2. Explain the basic function of C.R.O.
3. Why isolation transformer is needed?
4. State the function of electron gun.
5. What is name of the wave shape displayed?

REFERENCE:

1. Laboratory manual for basic electrical engineering.
2. Reference manual of general purpose Oscilloscope selected for the experiment.

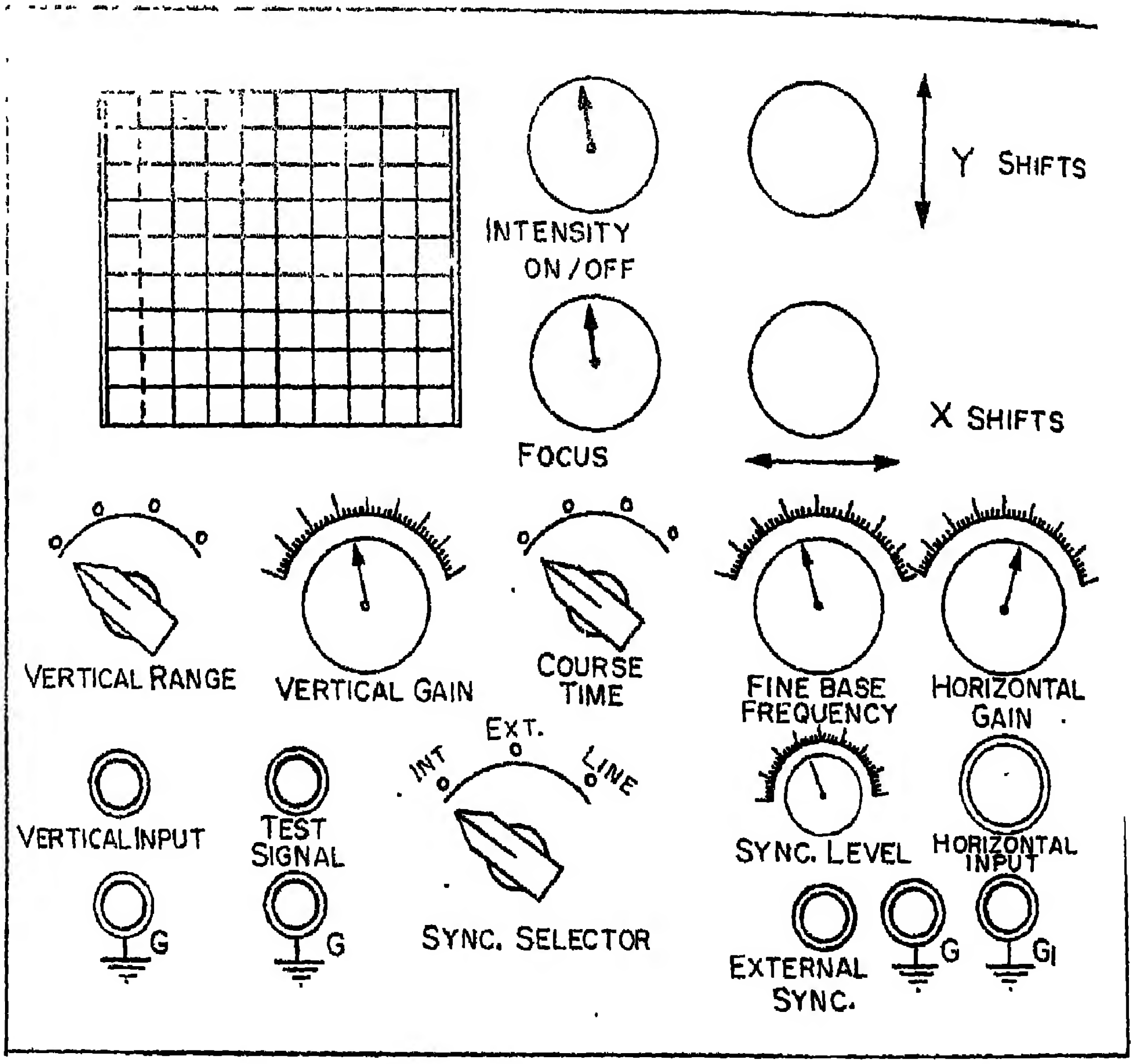

INTENSITY
ON / OFF
Y SHIFTS
FOCUS
X SHIFTS
VERTICAL RANGE
VERTICAL GAIN
COURSE TIME
FINE BASE FREQUENCY
HORIZONTAL GAIN
EXT.
INT
LINE
VERTICAL INPUT
TEST SIGNAL
SYNC. SELECTOR
SYNC. LEVEL
HORIZONTAL INPUT
G
G
EXTERNAL SYNC.
G
G

Fig 21·1

APPENDIX-I.

LIST OF CONTRIBUTORS

1. Dr.V.K.Bhansali
Associate Professor
Electrical Engineering Department
University of Jodhpur
Jodhpur-342001 (Rajasthan)

2. Shri J.L.Kankriya
Associate Professor
Electrical Engineering Department
University of Jodhpur
Jodhpur-342001 (Rajasthan)

3. Shri G.S.Srinivasan
Kamalalaya, No.4 Balakrishna Road
Mylapore, Madras-600004.

4. Shri M.S.Mittal
Deputy Director (Training)
Directorate of Industrial Training and
Vocational Education
Government of Haryana
Chandigarh.

5. Shri V.G.Phadke
Deputy Director of Training
Advanced Training Institute
Sion Trombay Road
Bombay-400022.

6. Shri G.V.D.Singh
Head, Electrical Engineering Department
Hewett Polytechnic
Mahanagar, Lucknow (U.P.)

7. Shri Yash Pal Kapoor
Lecturer in Electrical Engineering
M.A.C. College of Technology
Bhopal-462007 (M.P.)

8. Shri Syed Naseer Ali
Lecturer (Electrical Engineering)
YMCA Institute of Engineering
Faridabad-121006 (Haryana)

9. Shri A.A.Manikyaraja
Assistant Director
Advanced Training Institute
Guindy, Madras-600032.

10. Shri P.B.Ghosh
Assistant Training Officer
Advanced Training Institute
Sion - Trombay Road
Bombay-400022.

11. Shri ..P.V .ma
R al r in T chnology
Deparun.n. of Vocacirnalizacion of Educacion
N.C.E.R.T., NIE Campus
Sri Aurobindo Marg, N w D-lhi-110016.

12. Shri Sachchidananda Ray
L_ccur_r in T_chnology
D_parinen. of Vocacionalization of Education
N.C.E.R.T., NIE Campus
Sri Aurobindo Marg, N w D-lhi-110016.

APPENDIX-II

REVIEW AND EDITING COMMITTEE

1. Dr. [illegible].K. Jain
Professor and Chairman
Electrical Engineering Department
Regional Engineering College
Kurukshetra-132119 (Haryana)

2. Dr. [illegible].K. Bhan[illegible]
Associate Professor
Electrical Engineering Department
University of Jodhpur
Jodhpur-342001 (Rajasthan)

3. Shri [illegible].P. Mi[illegible]al
Deputy Director (Training)
Directorate of Industrial Training &
Vocational Education
Government of Haryana
Chandigarh.

4. Shri Sachchidananda Ray
Lecturer in Technology
Department of Vocationalization of Education
National Council of Educational-
Research and Training
Sri Aurobindo Marg, New Delhi-110016.

APPENDIX-III

Questionnaire for-Collecting Opinion of
Teachers and Students

on the
Instructional-cum-Practical Manual

On

ELEMENTS OF ELECTRICAL TECHNOLOGY

for

Lineman Vocation Class-XII

(Experimental Edition)

1984

DEPARTMENT OF VOCATIONALIZATION OF EDUCATION

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

SRI AUROBINDO MARG, NEW DELHI - 110016.

Dear Teacher/Student,

We are happy to place this Manual at your disposal with the hope that it will help you to conduct the practical works prescribed in the syllabi and to gain required competencies through vocational experience.

This Manual conforms to the syllabi of Lineman Vocation Class-XII offered by the State of Haryana and includes most of the important activities to be performed by a Lineman. This is an experimental edition with ample scope for further improvement through feedback from you. We solicit your active cooperation for the improvement of the Manual.

After having used this Manual for a year or more, kindly read the appended questionnaire carefully and write down the answers precisely and exactly to the point. You may use additional sheets of paper, 'if the space provided' is insufficient. The questionnaire may be mailed at the following address:

Shri SACHCHIDANANDA RAY
Programme Co-ordinator
Department of Vocationalization of Education
National Council of Educational
Research and Training
Sri Aurobindo Marg
NEW DELHI-110016.

QUESTIONNAIRE FOR THE TEACHERS

INSTRUCTIONAL-CUM-PRACTICAL MANUAL ON ________________

A. Name of the Teacher
(in block letters) ________________

B. Name & Postal Address
of the Institution ________________

____

____

____

C. i. Qualification ________________

ii. Teaching Experience ________________

iii. Professional or
Field Experience ________________

____

1. Do the activities covered in the Manual develop vocational expertise in the students?

YES / NO

2. List the activities included in the Manual which do not figure in the syllabus

3. List the activities included in the Manual which do not figure in the syllabus, but are vocationally important

4. List the activities prescribed in the syllabus but not covered in the Manual.

5. List the vocationally important activities which are neither included in the Manual nor prescribed in the syllabus.

6. a) Does the relevant information given under every activity unit furnish enough theoretical background of the activity?

Yes/No

b) If not, list the activity units where relevant information needs further modification.

Activity Unit	Portion	Type of modification needed

7. a) Does the relevant information contain any factual errors or inaccuracies?

Yes/No

b) If yes, give the details

Activity Unit	Error/Inaccuracy	Should read

8. Did you notice any expressions/sentences in the manual which do not carry precise meaning or information? If yes, then give the details:

Page No.	Expression/Sentence	Would be more appropriate

9. Are instructional objectives pertaining to each activity unit rational? If not, list down the irrational, irrelevant or vague ones.

Activity Unit	Irrational/irrelevant/ Vague objective

10. Does accomplishment of the activity units result in realization of objectives in terms of behavioural outcomes in the pupil? If not point out the behavioural outcomes mentioned in the manual, which you feel are difficult to achieve through a particular activity unit?

Activity Unit	Behavioural outcome

11. Is th procedure for activity units well sequential ? If not point out the discrepancies along with your own observations or suggestions.

Activity Unit	Discrepancy	Observation/ Suggestions

12. Did you notice any inaccuracies/discrepencies in the diagrames illustrating activity units? If yes, point them out.

Illustration No.	Discrepancy/ Inaccuracy

13. Your overall opinion about the Manual which may be useful in the effective improvement of the manual.

9

QUESTIONNAIRE FOR THE PUPILS

INSTRUCTIONAL-CUM-PRACTICAL MANUAL ON ______________________

A. Name of the pupil (in block letter) : ______________________

B. Name and address of the school/college : ______________________

____

C. Class ______________________

D. Medium of instruction ______________________

1. Enlist the portions of the Manual which you found difficult to understand and give reasons.

Activity Unit	Portion of the Text	Difficulty experienced

2. Mention the places where you found the language to be difficult.

Activity Unit	Page No.	Difficulty experienced

3. Point out the figures/illustrations which do not help in understanding the topic/theme.

Illustration No.	Yours observations/ difficulty experienced

4. Can you conduct the activity units yourself with the help of this manual?

Yes/No

If not, point out the portions of activity units which need further elaboration or explanation.

Activity Unit	Portions to be elaborated

5. Was theoretical information given in the manual useful to you in the examination?

Yes/No

6. Do you know the scientific reason behind steps that you take in the conduct of different activity units?

Yes/No

7. Your overall opinion about the manual.